Sihvola and Lindberg (editors) RAD Research and Education 2010 Aalto University

Department of Radio Science and Engineering

RAD Research and Education 2010

Ari Sihvola and Stina Lindberg (editors)

Aalto University

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Ari Sihvola and Stina Lindberg (editors)

Aalto University
School of Electrical Engineering
Department of Radio Science and Engineering

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1. Introduction

The Department of Radio Science and Engineering (RAD) is a small but essential part of the Aalto University, a new University formed in January 2010 as a merger of three universities: Helsinki University of Technology, Helsinki School of Economics, and the University of Art and Design in Helsinki. Located in Otaniemi, Espoo, the RAD department belonged in 2010 as one of the seven departments to the Faculty of Electronics, Communications, and Automation, of the Aalto School of Science and Technology.

The RAD Department in the Otaniemi campus of the Aalto University, is presently within the School of Electrical Engineering. In 2010, the organization of the university was different: the building in the picture (housing the Faculty of Electronics, Communications, and Automation) formed part of the School of Science and Technology.

For the Finnish university environment in general, for the RAD department in particular, year 2010 was again time of structural and organizational changes. This was the full first year when the new Aalto University existed as a formal institution. At the same time, the 100-year old Helsinki University of Technology (TKK) disappeared. This change was not insignificant. The history of TKK can be traced back to mid-19th century when it was founded as the rather modest Helsinki Technical School. The institution was granted university status in 1908 by Emperor Nicholas II who was the Grand Prince of Finland until his abdication in 1917.

In the beginning of 2010, the old TKK was transformed into the School of Science and Technology within the structure of Aalto University. This organizational configuration only lasted for one year; starting from January 2011, the School of Science and Technology was divided into four schools. The RAD unit became one of the departments of the Aalto University's School of Electrical Engineering.

In this report, which describes the activities of the Department of Radio Science and Engineering, the following abbreviations occur often:

- RAD: Department of Radio Science and Engineering (Radiotieteen ja -tekniikan laitos)
- TKK: Helsinki University of Technology (Teknillinen korkeakoulu)
- SMARAD: Centre of Excellence in Smart Radios and Wireless Research
- GETA: The Finnish Graduate School in Electronics, Telecommunications, and Automation
- IEEE: Institute of Electrical and Electronics Engineers
- URSI: International Union of Radio Science (Union Radio-Scientifique Internationale)

– SA: Academy of Finland (Suomen Akatemia)
– EU: European Union (Euroopan unioni)
– ESA: European Space Agency (Euroopan avaruusjärjestö)
– VTT: Technical Research Centre of Finland (Valtion teknillinen tutkimuskeskus)

2. Finances

The total budget of the Department of Radio Science and Engineering was 6696 800 € (in 2009, the corresponding figure was 6051 000 €). From this amount, the funding through the university budget (including special funding for SMARAD) was 2772 800 € (2379 000 €), which is 34% (39%) of the total. Most of the researchers and students working in the RAD Department were paid from project funding, which amounted to 3924 000 € (3672 000 €), meaning 66 % (61%) of the total expenses.

Project funding from external sources in 2009 and 2008 for research was as follows (in euros):

	2010	2009
Academy of Finland (SA)	1 340 000	1 140 000
Technology Development Center (TEKES)	732 000	601 000
National Graduate School GETA	180 000	167 000
EU	466 000	218 000
ESA and other international partners	600 000	603 000
Finnish industry and other domestic funding	606 000	943 000
TOTAL	**3 924 000**	**3 672 000**

3. Research Teams in the RAD Department

For administrative purposes, it is helpful to divide the research personnel in the RAD department into the following groups, even if the division is artificial in some respects. Interaction between the teams is strongly encouraged and several co-operation efforts are ongoing.

1. **Millimeter Wave Techniques.** The research group is led by Prof. Antti Räisänen. There are 4 other senior scientists with a doctoral degree (Juha Mallat, Juha Ala-Laurinaho, Sergey Dudorov, and Dmitri Lioubtchenko) and 7 researchers working towards their doctoral degree. In addition, Professor Constantin Simovski works half-time in this group.
2. **Advanced Artificial Materials and Smart Structures.** This research group is led by Prof. Sergei Tretyakov. The research group includes 2 senior scientists, and 3 researchers working towards their doctoral degree. In addition, Professor Constantin Simovski works half-time in this group.
3. **RF Applications in Mobile Communications and Non-Destructive Testing.** This research group is led by Prof. Pertti Vainikainen. There are 5 other senior scientists with a doctoral degree (Clemens Icheln, Tommi Laitinen, Outi Kivekäs, Katsuyuki Haneda, and Valeri Mikhnev) and 7 researchers working towards their doctoral degree.
4. **Wave–Material Interaction.** The research group is led by Academy Professor Ari Sihvola. The group contains 2 other senior scientists with doctoral degree (Professor Emeritus Ismo Lindell and Henrik Wallén), and 5 researchers working towards their doctoral degree.
5. **Computational Electromagnetics.** The group is led by Professor Keijo Nikoskinen. The group contains 6 other senior scientists with doctoral degree (Tero Uusitupa, Sami Ilvonen, Jari Hänninen, Pasi Ylä-Oijala, Seppo Järvenpää, and Matti Taskinen), and 4 researchers working towards their doctoral degree.
6. **Space Technology.** The research group is led by Professor Martti Hallikainen. The group contains one other senior scientist with doctoral degree (Sampsa Koponen), and 5 researchers working towards their doctoral degree.
7. **Circuit Theory, Simulation, and Modeling.** The research group is led by Prof. Martti Valtonen. There are 3 other senior scientists with a doctoral degree (Janne Roos, Kimmo Silvonen, and Timo Veijola) and 5 researchers working towards their doctoral degree.

4. Personnel

The number of permanent, full-time employees in the Department of Radio Science and Engineering financed by the University budget was 37 on December 31, 2009. The total number of employees working in the Department of Radio Science and Engineering during the year 2010 was 126.

Ala-Laurinaho, Juha, D.Sc. (Tech.)	Senior scientist
Alitalo, Pekka, D.Sc. (Tech.)	Post-doctoral researcher
Allen, Mark, M.Sc. (Tech.)	Research associate
Bergamin, Luzi, Ph.D.	Post-doctoral researcher until 30.11.
Bin Abdullah Al-Hadi, Azremi, M.Sc.	Research associate
Chicherin, Dmitry, Lic.Sc. (Tech.)	Research associate
Costa, Luis, Lic.Sc. (Tech.)	University teacher
Dahlberg, Krista, M.Sc. (Tech.).	Research associate
Doudorov, Sergey, D.Sc. (Tech.)	Post-doctoral researcher, on leave of absence 31.5.-30.11.
Du, Zhou, M.Sc.	Research associate
Generalov, Andrey, M.Sc.	Doctoral student from 25.10, summer trainee 1.6.-30.6.
Geng, Suiyan, Lic.Sc. (Tech.)	Research associate until 31.8.
Hakkarainen, Anssi, Mr.	Research assistant
Hallikainen, Martti, D.Sc. (Tech.)	Professor
Haneda, Katsuyuki, D.Sc.	Post-doctoral researcher
Holopainen, Jari, Lic.Sc. (Tech.)	Research associate
Honkala, Mikko, Lic.Sc. (Tech.)	Research associate
Hulkkonen, Mikko, Mr.	Research assistant
Hänninen, Jari, D.Sc. (Tech.)	Senior scientist, Department communications liaison
Icheln, Clemens, D.Sc. (Tech.)	Lecturer
Ilvonen, Janne, M.Sc. (Tech.)	Research associate
Ilvonen, Sami, D.Sc. (Tech.)	Post-doctoral researcher
Jiaran, Qi, M.Sc. (Tech.)	Research associate
Järveläinen, Jan, Mr.	Research assistant from 8.2.
Järvenpää, Seppo, Ph.D.	Senior scientist
Kahra, Eino, Mr.	Laboratory technician
Kainulainen, Juha, M.Sc. (Tech.)	Research associate
Kanevska, Valentyna, M.Sc.	Project coordinator, on leave of absence from 1.6.
Kangasperko, Leena, BBA	Secretary until 31.8.
Karilainen, Antti, M.Sc. (Tech.)	Research associate
Karttunen, Aki, Lic.Sc. (Tech.)	Research associate
Kataja, Juhani, M.Sc. (Tech.)	Research associate
Keltikangas, Kirsti, M.Sc. (Educ.)	Research associate
Kettunen, Henrik Lic.Sc. (Tech.)	Research associate
Kestilä, Antti, M.Sc.	Research associate until 30.6.
Khatun, Afroza Mst, M.Sc.	Research associate
Kiminki, Sami, M.Sc. (Tech.)	Research associate
Kiuru, Tero, M.Sc. (Tech.)	Research associate
Kivekäs, Outi, D.Sc. (Tech.)	Post-doctoral researcher
Kolmonen, Veli-Matti, D.Sc. (Tech.)	Post-doctoral researcher
Koponen, Sampsa, D.Sc. (Tech.)	Post-doctoral researcher
Kyrö, Mikko, M.Sc. (Tech.)	Research associate
Laakso, Ilkka, Lic.Sc. (Tech.)	Research associate
Laakso, Lauri, Mr.	Laboratory technician
Laitinen Tommi, D.Sc. (Tech.)	Senior scientist, pro term professor from 17.5.
Lehtovuori, Anu, Lic.Sc. (Tech.)	University teacher
Leppävirta, Johanna, M.Sc. (Educ.)	Research associate
von Lerber, Annakaisa, M.Sc. (Tech.)	Research associate
Lesnyak, Natalia, M.Sc.	Project secretary, on leave of absence
Li Yanfeng, B.Sc.	Research assistant until 30.10.
Lindberg, Stina, B.Sc. (Econ.)	Secretary
Lindell, Ismo, D.Sc. (Tech.)	Professor emeritus
Lioubtchenko, Dmitri, Ph.D.	Docent, Academy research fellow

Luukkonen, Olli, D.Sc. (Tech.)	Post-doctoral researcher, leave of absence until 31.8.
Mallat, Juha, D.Sc. (Tech.)	Teaching scientist
Maksimovitch, Yelena, Dr.	Senior scientist 19.7.–31.8.
Markkanen, Johannes, M.Sc.(Tech.)	Research associate
Medina Acosto, Gerardo, M.Sc.	Research associate from 1.10.
Miettinen, Pekka, Lic.Sc. (Tech.)	Research associate, on leave of absence from 31.10.
Mikhnev, Valeri, Dr.	Senior scientist 1.7.–31.8. and 22.11.–13.12.
Morits, Dmitry, M.Sc.	Research associate
Mylläri, Tuula, Ms.	Secretary, on leave of absence 19.1.–13.8.
Muttilainen, Anna, B.Sc.(Tech.).	Research assistant from 24.5.
Nagy, Sorana, M.Sc. (Econ.)	Project secretary
Nefedov, Igor, Dr.Sc.	Senior scientist
Niemi, Teemu, Mr.	Research assistant until 31.8.
Nieminen, Markku, M.Sc. (Tech.)	Laboratory manager
Nikoskinen, Keijo, D.Sc. (Tech.)	Professor, Deputy Head of the department
Nykänen, Katrina, Ms.	Secretary
Olkkonen, Martta-Kaisa, M.Sc. (Tech.)	Research associate
Otewa, Strasdosky, Mr.	Research assistant until 31.10.
Parveg, Dristy, M.Sc.	Research associate from 16.12.
Pitkonen, Mikko, D.Sc. (Tech.)	Research associate until 31.5.
Planman, Irma, Ms.	Secretary
Pousi, Patrik, D.Sc. (Tech.)	Senior scientist
Pohjala, Anna, Lic.Sc. (Tech.)	Research associate until 31.8.
Podlozny, Vladimir, Ph.D.	Project manager and senior scientist
Poutanen, Juho, Lic.Sc. (Tech.)	Research associate
Praks, Jaan, M.Sc.	Teaching assistant
Rantanen, Jouko, Mr.	Process Engineer (pilot) 21.5–30.6.
Rapoport, Yuri, Dr.	Visiting professor from 1.9.
Rasilainen, Kimmo, Mr.	Research assistant
Rimpiläinen, Tommi, Mr.	Research assistant from 18.5.
Robertson, Jean-Baptiste, M.Sc.Eng	Project coordinator from 1.6.
Roos, Janne, D.Sc. (Tech.)	Senior scientist (working externally with Grant of the Academy of Finland)
Rouhe, Erkka, Mr.	Process engineer
Rummukainen, Pekka, Mr.	Laboratory technician
Räisänen, Antti, D.Sc. (Tech.)	Professor, Head of the department
Schmuckli, Lorenz, Mr.	Laboratory technician
Seppänen, Jaakko, M.Sc. (Tech.)	Research associate
Sievinen, Pauli, Mr.	Research assistant
Sibakov, Viktor, M.Sc. (Tech.)	Laboratory manager
Sihvola, Ari, D.Sc. (Tech.)	Professor, Academy professor until 30.7.
Silvonen, Kimmo, D.Sc. (Tech.)	Senior lecturer
Simola, Jarno, Mr.	Research assistant until 30.6.
Simovski, Constantin, Dr.Sc.	Visiting professor
Suoranta, Tanya, Ms.	Project secretary 1.6.–15.11.
Tamminen, Aleksi, M.Sc. (Tech.)	Research associate
Taskinen, Matti, D.Sc. (Tech.)	Senior scientist
Tiuri, Martti, D.Sc. (Tech.)	Professor emeritus
Toivanen, Juha, M.Sc. (Tech.)	Research associate
Tretyakov, Sergei, Dr.Sc.	Professor
Uusitupa, Tero, D.Sc. (Tech.)	Post-doc researcher
Vaaja, Matti, Lic.Sc. (Tech.)	Research associate
Valagiannopoulos, Constantinos, Dr.	Post-doc researcher
Valkonen, Risto, M.Sc. (Tech.)	Research associate
Vainikainen, Pertti, D.Sc. (Tech.)	Professor
Wallén, Henrik, D.Sc. (Tech.)	Post-doc researcher, university teacher
Valtonen, Martti, D.Sc. (Tech.)	Professor
Vehmas, Joni, Mr.	Research assistant from 19.5.
Veijola, Timo, D.Sc. (Tech.)	Laboratory manager
Virtanen, Jarmo, Lic.Sc. (Tech.)	Senior research scientist
Ylä-Oijala, Pasi, Ph.D.	Docent, senior scientist, Academy research fellow until 31.7.
Zvolensky, Tomas, M.Sc.	Research associate from 1.3.

Exchange Students and Summer Trainees

Hevosoja, Jani	24.5.–22.8.
Beuerle, Bernhard, B.Sc.	Stipendiary until 30.6.
Gorrono Vinegla, Javier	Erasmus stipendiary 2.2.–31.10.
Dashti, Marzieh, M.Sc.	CIMO stipendiary until 31.3.
Martinez Navarrete, Laura, B.Sc.	Erasmus stipendiary until 30.6.
Kauppinen, Christoffer	17.5.–31.8.
Lankinen, Mikko	24.5.–31.8.
Lindeberg, Finn	31.5.–31.8.
Palacios Morales, Alvaro	Erasmus stipendiary 1.2.–31.7.
Parkkila, Mikko	Research assistant 1.6.–14.7.
Piiroinen, Kalle	Research assistant 17.5.–16.8.
Xu, Lei, Mr.	Research assistant from 25.5.

Docents

Alanen, Esko, D.Sc. (Tech.)	Electromagnetics. Affiliated with the University of Kuopio
Kettunen, Lauri, D.Sc. (Tech.)	Computational electromagnetics. Professor, Tampere University of Technology
Lehto, Arto, D.Sc. (Tech.)	Radio engineering
Lioubtchenko, Dmitri, Ph.D.	Millimeter and submillimeter waves. Affiliated with Academy of Finland
Luukanen, Arttu, D.Sc. (Tech.)	THz technology. Research professor, Director of MilliLab, VTT
Oksanen, Markku, D.Sc. (Tech.)	Electromagnetics. Affiliated with Pöyry Group
Pulliainen, Jouni, D.Sc. (Tech.)	Remote sensing. Professor, Finnish Meteorological Institute
Rahola, Jussi, D.Sc. (Tech.)	Computational Electromagnetics. Affiliated with Optenni Ltd.
Salonen, Erkki, D.Sc. (Tech.)	Radio engineering. Affiliated with University of Oulu
Somervuo, Pekka, D.Sc. (Tech.)	Radio engineering. Affiliated with Nokia
Tolmunen, Timo, D.Sc. (Tech.)	Radio engineering. Affiliated with Turku Polytechnic
Tornikoski, Merja, D. Sc. (Tech.)	Radio astronomy. Director of Metsähovi Radio Observatory
Tuovinen, Jussi, D.Sc. (Tech.)	Radio engineering. Research Professor, Vice President, VTT
Valtaoja, Esko, Ph.D.	Radio astronomy. Professor, University of Turku
Viikari, Ville, D.Sc. (Tech.)	Wireless sensors and antenna measurements. VTT
Viitanen, Ari, D.Sc. (Tech.)	Electromagnetics
Ylä-Oijala, Pasi, Ph.D.	Computational Electromagnetics

5. International Visits and Visitors

5.1 Short Visits by Foreign Scientists

- Ph.D. Arkadi Chipouline, Friedrich-Schiller-Universität, Jena, Germany, 3 days
- Prof. Alexey Vinogradov, Institute for Theoretical and Applied Electromagnetics – ITAE, Russia, 10 days
- M.Sc. Michal Pokorný, Brno University of Technology, Czech Republic, one week
- D.Sc. Ilya Ryzhikov, Institute for Theoretical and Applied Electromagnetics – ITAE, Russia, 5 days
- M.Sc. Nikolay Menshikh, Institute for Theoretical and Applied Electromagnetics – ITAE, Russia, one week
- Ph.D. Andrey Lavrinenko, Technical University of Denmark (DTU), Denmark, 3 days
- Dr. Silke Britzen, Max Planck Institute for Astronomy, Berlin, Germany, 27-29 May
- Prof. Ahmet S. Turk, Yildiz Technical University, Istanbul, Turkey, 3 days
- Prof. Andrei Lavrinenko, Technical University of Denmark. Visiting lecture "Three-dimensional metal-dielectric structures for optical and THz applications: design and fabrication", 1 day
- Ph.D. Cumali Sabah, Wolfgang Goethe-Universität, Germany, 2 weeks
- Prof. Ahmed Kishk, University of Mississippi, USA, 1 day
- Prof. Michael Havrilla, Air Force Institute of Science Technology, USA, 1 day
- Prof. V.E. Lyubtchenko, Institute of Radioengineering and Electronics, RAS, Russia, 1 day

5.2 Extended Visits by Foreign Scientists

- Dr. Valeri Mikhnev, The Institute of Applied Physics, Minsk, Belorussia, 1 July – 31 August and 22 November – 13 December
- Dr. Yelena Maksimovitch, The Institute of Applied Physics, Minsk, Belarus, 19 July – 31 August
- B.Sc. Laura Martinez Navarrete, Polytechnical University of Valencia, Spain, until 30 June
- B.Sc. Javier Gorroño Viñegia, Polytechnical University of Valencia, Spain 20 February - 30 September
- M.Sc. Marzie Dashti, Tokyo Institute of Technology until 31 March
- B.Sc. Alvaro Palacios Morales, Polytechnical University of Catalunya, 1 February – 31 July
- Prof. Yuriy Rapoport, Taras Shevchenko University, Kiev, Ukraine, 1 September-31 December
- M.Sc. Nilüfer Özdemir, University of Louvain, Belgium, 25 October – 25 November
- M.Sc. Gerardo Medina, Polytechnic University of Catalunya, Spain from 1 October

5.3 Visits in Foreign Institutes by RAD Scientists

- D. Sc. (Tech.) Olli Luukkonen, University of Pennsylvania, USA, until 30 August
- M.Sc. (Tech.) Juha Kainulainen, European Space Astronomy Centre, Spain, 11-16 and 24-29 January
- M.Sc. Mst. Afroza Khatun, Tokyo Institute of Technology, 1 June – 30 November
- D.Sc. (Tech.) Sergey Dudorov, Royal Institute of Technology, 1 June – 30 March
- M.Sc. (Tech.) Juha Toivanen, Chalmers University of Technology, 1-26 February
- M.Sc. (Ed.) Johanna Leppävirta, Auckland University, New Zealand, all year
- M.Sc. (Ed.) Kirsti Keltikangas, Linköping University, Sweden 26 January – 25 February
- D.Sc. (Tech.) Juha Ala-Laurinaho, Brno, Czech Republic 26-29 April

6. Awards, Honors and Prizes

Aleksi Tamminen won the Best Student Paper Award at GSMM2010 conference held on April 14-16, 2010, in Incheon, Republic of Korea. Aleksi's paper is titled "Wide-band measurements of antenna-coupled microbolometers for THz imaging".

Professor Emeritus Ismo Lindell received the State Award for Public Information for his book on the history of electrical engineering *Sähkön pitkä historia* (454 pp., Gaudeamus Helsinki University Press, 2009). The Minister of Education of the Government of Finland, Henna Virkkunen, presented the award to him on 28 April.

Professor Martti Hallikainen received the Fiorino d'Oro (Golden Florin) Award of Centro Telerilevamento Microonde for his leadership and outstanding contribution to research in microwave remote sensing of land surfaces. The award was presented to him on 7 October at the URSI Commission F Microwave Signatures 2010 Specialist Symposium on Microwave Remote Sensing of the Earth, Oceans and Atmosphere, Florence, Italy.

7. Teaching

SPRING SEMESTER COURSES in 2010 (periods III and IV)

S-26.2300 Radio Frequency Measurements for 3rd year students (2 credits), J. Mallat and course assistants. Basics of radio-frequency measurements, laboratory experiments on impedance measurement, spectrum measurement, and RF device measurement.

S-26.2350 Parts of Radio Communications Systems for 4th year students (3 credits), C. Icheln, P. Vainikainen, T. Laitinen, and V.-M. Kolmonen. Structures of radio communications systems, transmitters, receivers, phase locking, noise, modulation, nonlinearities, link budget.

S-26.3000 Radio Engineering special assignment for 4th year students or postgraduate students (3–8 credits), A. Räisänen, S. Tretyakov, P. Vainikainen, J. Mallat, and staff. Individual projects in connection with radio engineering research conducted in the Department of Radio Science and Engineering.

S-26.3060 Research Seminar on Radio Science and Engineering for 4th year and postgraduate students (1 credit), professors in the department. Weekly seminar lectures on research projects. Several visiting lectures from other research laboratories and institutes or from industry.

S-26.3120 Radio Engineering laboratory course for 4th year students (7 credits), C. Icheln and course assistants. Microwave measurements: theory and equipment. Laboratory experiments on antenna measurements, GSM transmitter, and GSM receiver. In the spring semester: design, fabrication, and measurement of a transistor amplifier.

S-26.3301 Radio Systems in Telecommunication II for 4th year students (3 credits), P. Mikkola and other adjunct teachers from industry. Technology of radio links and equipment.

S-26.3342 Radar Engineering for 4th year students or postgraduate students (4 credits), O. Klemola. Operating principle of pulsed radar, radar equation, clutter, electronic warfare, radar applications, etc.

S-26.3392 Electromagnetic Compatibility for 4th year students or postgraduate students (4 credits), S. Tretyakov, P. Vainikainen. Electromagnetic compatibility and testing.

S-26.4000 Postgraduate Course in Radio Science and Engineering (3–10 credits), annually varying topics. Spring term 2010: J. Pulliainen, Data interpretation and modeling methods in remote sensing.

S-55.1100 Basics of Electrical and Electronics Engineering for 1st and 2nd year students (4 credits, not for electrical engineering students), K. Silvonen, L. Costa. Students learn the basics of electrical and electronics technology. Laboratory experiments.

S-55.1220 Circuit Analysis 2 for 1st year students (5 credits), M. Valtonen, A. Lehtovuori, assistants. Analyzing the transient behavior of circuits using the Laplace transform, concepts pertaining to system functions, and the operation of transmission-line circuits in both the time and the frequency domain, also the use of the Smith chart. This course is also taught using the Problem Based Learning (PBL) approach.

S-55.3110 Network Synthesis for 3rd year students (5 credits), A. Lehtovuori. Realizing driving point functions and transfer functions using both passive and active circuits, concept of a transmission zero, comparison of different filter realizations.

S-55.3210 Numerical Circuit Design Methods for 4th year and postgraduate students (5 credits), J. Virtanen, M. Honkala. Numerical methods used in circuit simulation and programming the numerical algorithms. Computer exercises.

S-55.3130 Active Filters for 4th year students and postgraduate students (5 credits), J. Holmberg. The design and realization methods of advanced active filters.

S-92.3121 Satellite Communications (3 credits), L. Kurvonen. Satellite communication systems, structure and operation of ground stations, influence of radiowave propagation phenomena on satellite communication.

S-92.4135 Microwave Remote Sensing, for postgraduate students (5 credits), K. Rautiainen. Microwave radiometers and synthetic aperture radars. Basics of polarimetry and interferometry and their use in remote sensing instruments. Applications.

S-92.3186 Laboratory Course in Space Technology (4 credits), J. Praks. Laboratory exercises in spaceflight instrumentation technology and remote sensing and their applications.

S-92.3192 Special Assignment in Space Technology (5 credits), M. Hallikainen, J. Praks. An assignment on the development and use of space technology and its applications. The assignment may be a theoretical and/or experimental investigation, including a final report. The assignment may also be carried out by a group of students.

S-96.1121 Dynamic Field Theory for 2nd year students (5 credits), K. Nikoskinen and course assistants. Undergraduate level basic electromagnetics course required of most ECE students, part 2.

S-96.3171 Difference Methods in Electromagnetics for 4th year and postgraduate students (5 credits), S. Ilvonen, L. Costa, M. Taskinen, and T. Uusitupa as the course assistant. Introduction to the finite-difference time-domain method in electromagnetics.

S-96.3175 Package Programs in Electromagnetics for 4th year and postgraduate students (5 credits), K. Nikoskinen, S. Tretyakov, H. Wallén, M. Taskinen, J. Holopainen, and course assistants. Introduction to three commercial software packages for computation of electromagnetic fields in radio engineering applications.

S-96.3191 Special Project in Electromagnetics for 4th year students (3–5 credits), K. Nikoskinen, A. Sihvola. Research project on a chosen electromagnetic problem.

S-96.3211 Waveguides and Resonators for 4th year students (5 credits), J. Hänninen. Free and guided waves, waveguide and resonator structures.

AUTUMN SEMESTER COURSES in 2010 (periods I and II)

S-26.1100 Orientation Course for Studies of Electronics and Electrical Engineering for 1st year students (1 credit), A. Räisänen and personnel of the department. General information of the university, studies, and motivation for the studies of mathematics, physics, computer science, etc.

S-26.2100 Foundations of Radio Engineering for 3rd year students (5 credits), A. Räisänen. Transmission lines and waveguides, basic microwave components and circuits, antennas, radio wave propagation, radio systems, applications.

S-26.2110 Fundamentals of Radio Engineering for master's program students (5 credits), A. Räisänen. Transmission lines and waveguides, basic microwave components and circuits, antennas, radio wave propagation, radio systems, applications.

S-26.2900 Elements of Electromagnetic Field Theory and Guided Waves for master programme students (8 credits), C. Simovski. Basics for electromagnetic field theory and guided waves. Maxwell's equations, material equations, boundary conditions, etc. Ohm's law, Kirchhoff's law, phasors, Poynting theorem, Smith chart, plane waves, waves in waveguide, resonators etc.

S-26.3000 Radio Engineering special assignment for 4th year students or postgraduate students (3–8 credits), A. Räisänen, S. Tretyakov, P. Vainikainen, J. Mallat, and staff. Individual projects in connection with radio engineering research conducted in the Radio Laboratory.

S-26.3060 Research Seminar on Radio Science and Engineering for 4th year and postgraduate students (1 credit), professors of the department. Weekly seminar lectures on research projects. Several visiting lectures from other research laboratories and institutes or from industry.

S-26.3120 Radio Engineering, laboratory course for 4th year students (7 credits), C. Icheln and course assistants. Microwave measurements: theory and equipment. Laboratory experiments on antenna measurements, GSM transmitter, and GSM receiver. In the spring semester design, fabrication, and measurement of a transistor amplifier.

S-26.3142 Radio Wave Propagation in Mobile Communications, for 4th or postgraduate students (3 credits), P. Vainikainen. Basic mechanisms, properties of materials, propagation in different environments, propagation models, measurement techniques.

S-26.4000 Postgraduate Course in Radio Science and Engineering (3-8 credits), annually varying topics. Autumn term 2010: Y. Rapoport, Selected topics on Oscillations and Waves with applications to Radio Science and Engineering.

S-55.1100 Basics of Electrical and Electronics Engineering for the 1st and 2nd year students (4 credits, not for electrical engineering students), K. Silvonen, L. Costa. Students learn the basics of electrical and electronics technology. Laboratory experiments.

S-55.1210 Circuit Analysis 1 for 1st year students (5 credits), M. Valtonen, A. Lehtovuori, assistants. Students learn to analyze the operation of alternating and direct current circuits and understand the basic concepts of circuit analysis. This course is also taught using the PBL approach.

S-55.3120 Passive Filters for 4th year students and postgraduate students (5 credits), J. Virtanen. Use of tables to design elliptical and transmission line filters from given specifications and good a command of the theory behind filter design.

S-55.3230 Circuit Simulation for 3rd year students (4–5 credits), L. Costa. Students learn the fundamental use of a circuit simulator and they understand the possibilities and limitations of the circuit simulator.

S-92.3110 Radio Science for space and environmental applications (2 credits), J. Praks. The course gives an overview on space environment, current trends in space technology, and remote sensing instruments and applications. The following application topics will be covered: environmental disaster assessment from space, climate change monitoring, interplanetary exploration, deep space missions, cosmology and radio astronomy and space research in Finland. During the course several visiting top lecturers from various space research and remote sensing institutes give general lectures about their topic.

S-92.3114 Spaceflight Instrumentation (6 credits), H. Koskinen. Design, construction and testing of spaceborne instruments and their integration in satellite. Reliability analysis. Satellite orbits and spaceflights. Examples of spaceflight instrumentation projects.

S-92.3132 Remote Sensing (6 credits), M. Hallikainen. Active (radar, lidar) and passive (scanner, radiometer, spectrometer) remote sensing instruments and their applications. Remote sensing satellites and their orbits.

S-92.4305 Special Problems in Space Technology (5 credits), M. Tornikoski. A varying topic of current interest on space technology. This year topic was radio astronomy and the Planck satellite.

S-96.1020 History of Electrical Engineering for undergraduate and postgraduate students (3 credits), A. Sihvola. Development of electromagnetics as a science and its applications in telecommunications and power engineering up till the first part of the 20th century.

S-96.1111 Static Field Theory for 2nd year students (5 credits), A. Sihvola and course assistants. Undergraduate level basic electromagnetics course required of most ECE students, part 1.

S-96.2180 Electromagnetic Simulations for 3rd year students (5 credits), K. Nikoskinen, H. Wallén. Introduction to two commonly used electromagnetic field simulation software packages and to the algorithms behind the programs.

S-96.3131 Electromagnetics for 3rd year students (5 credits), J. Hänninen and a course assistant. Solution methods for classical electromagnetic field problems.

S-96.3180 Advanced Electromagnetic Simulations for 4th year students and postgraduate students (5 credits), J. Holopainen, P. Alitalo, A. Karilainen, J. Ilvonen, C. Icheln, S. Järvenpää, and M. Taskinen. Practical skills and knowledge of solving high frequency electromagnetic problems and designs using computer-aided software tools. The students will acquaint themselves with two software tools for computational electromagnetic simulation. A short theoretical background of each tool is taught. (1st half of course, the 2nd half given in Spring 2011.)

S-96.3191 Special Project in Electromagnetics for 4th year students (3–5 credits), K. Nikoskinen, A. Sihvola. Research project on a chosen electromagnetic problem.

S-96.3330 Numerical methods in electromagnetics (5 credits), P. Ylä-Oijala and a course assistant. A course for 4th year and postgraduate students with a varying topic of numerical methods in electromagnetics. In autumn 2010 semester: Introduction to the method of moments (integral equation method) for solving static or dynamic electromagnetic problems.

8. Degrees

8.1 Doctor of Science (Technology)

Veli-Matti Kolmonen	Propagation channel measurement system development and channel characterization at 5.3 GHz *Supervisor:* Prof. Pertti Vainikainen *Thesis defence:* 28 April, 2010 *Opponent:* Prof. Matti Latva-aho (Oulu University) and D.Sc.(Tech.) Kimmo Kalliola (Nokia Oyj) *Preliminary examiners:* Dr. Yves Lostanlen VP Wireless CTO at Siradel, Toronto, Canada) and Prof. Jørgen Bach Andersen (Aalborg University), Denmark
Tommi Toivonen	Microwave dosimetry in biological exposure studies and in practical safety evaluations *Supervisor:* Prof. Pertti Vainikainen *Thesis defence:* 7 May, 2010 *Opponents:* Prof. Prof. Maila Hietanen (Finnish Institute of Occupational Health New Technologies and Risks) and Prof. Yngve Hamnerius (Chalmers University of Technology), Gothenburg, Sweden *Preliminary examiners:* Prof. Luc Martens (Ghent University), Belgium and Prof. Andrew W Wood (Swinburne University of Technology) Hawthorn, Australia
Mikko Pitkonen	Exact solutions for spherical electrostatic scattering problems *Supervisor:* Academy Prof. Ari Sihvola *Thesis defence:* 10 May, 2010 *Opponent:* Dr. Petri Ola *Preliminary examiners:* Prof. B.U. Felderhof (Institut für theoretische Physik A, RTWDH), Aachen, Germany, and Prof. Matti Lassas (University of Helsinki)
Elina Nieppola	Synchrotron emission from blazar jets – energy distributions and radio variability *Supervisor*: Prof. Martti Hallikainen *Thesis defence*: 28 May, 2010 Opponent: Ph.D. Silke Britzen, (Max-Planck-Institut für Radioastronomie), Bonn Germany Preliminary examiners: Dr. Jari Kotilainen (Tuorla Observatory), Piikkiö, Finland and Dr. Marc Türler (ISDC, University of Geneva), Switzerland
Juha Toivanen	Measurement methods for mobile terminal antenna performance *Supervisor*: Prof. (pro tem) Tommi Laitinen *Thesis defence*: 24 September, 2010 Opponents: Ph.D. Philip Miller (National Physical Laboratory), UK, and D.Sc. (Tech.) Jussi Rahola (Optenni Ltd) Preliminary examiners: Prof. Edward B. Joy, Boulder, Colorado, USA and Assoc. Prof. Buon Kiong Lau, (University of Lund), Sweden
Patrik Pousi	Active and passive dielectric rod waveguide components for millimetre wavelengths *Supervisor:* Prof. Antti Räisänen *Opponent:* Prof. Dr.-Ing. Lorenz-Peter Schmidt (Universität Erlangen-Nürnberg), Germany Thesis defence: 26 November, 2010 Preliminary examiners: Dr. Alex Schuchinsky, (Queens University), Belfast, N.I. and Prof. Andrea Neto (TU Delft), The Netherlands

8.2 Licentiate of Science (Technology)

Matti Vaaja	Design and realisation of L-band frequency scanning radiometer (L-alueen taajuuspyyhkäisevän radiometrin suunnittelu ja toteutus) *Graduation date*: 17 May, 2010

	Supervisor: Prof. Antti Räisänen Research done at TKK Department of Radio Science and Engineering
Mikko Kyrö	Wideband radio channel measurements and antennas for millimeter wave communications (Laajakaistaiset radiokanavamittaukset sekä antennit millimetriaaltoalueen tietoliikennesovelluksiin) *Graduation date:* 7 June, 2010 Supervisor: Prof. Pertti Vainikainen Research done at TKK Department of Radio Science and Engineering
Juho Poutanen	Radio wave propagation analysis for single and multilink MIMO channel models (Radioaaltojen etenemisen analysointi yhden ja usean linkin MIMO-kanavamalleja varten) *Graduation date*: 7 June, 2010 *Supervisor*: Prof. Pertti Vainikainen Research done at TKK Department of Radio Science and Engineering
Pekka Miettinen	Partitioning and macromodel-based model-order reduction for RLC circuits (Piirijakoon ja makromalleihin perustuva mallireduktio RLC-piireille) *Graduation date*: 12 April, 2010 *Supervisor*: Prof. Martti Valtonen Research done at TKK Department of Radio Science and Engineering
Juha-Petri Kärnä	Using statistical inversion for the retrieval of the geophysical parameters from remote sensing data (Geofysikaalisten parametrien estimointi kaukokartoitushavainnoista tilastollista inversiota käyttäen *Graduation date*: 12 April, 2010 *Supervisor*: Prof. Martti Hallikainen Research done at TKK Department of Radio Science and Engineering

8.3 Diploma Engineer (M.Sc. (Tech.))

Matti. T. Koskinen	Matkapuhelimen lähettimen tehonsäädön mallinnus (Modeling of transmitter power control) *Graduation date:* 15 February, 2010 *Supervisor:* Prof. Antti Räisänen Research done at Nokia Oyj
Aleksi Heikkilä	Syslog-tapahtumaviestien hyödyntäminen laajakaistaverkon ennakoivan ja varhaisen vianhallinnan kehittämisessä (Utilizing Syslog event messages in development of proactive and early fault management in broadband networking) *Graduation date:* 15 February, 2010 *Supervisor:* Prof. Antti Räisänen Research done at Elisa Oyj
Sami Häkkinen	Antennimittausten epävarmuuksien tarkastelu heijastuksettomassa huoneessa (Antenna measurement uncertainties in anechoic chamber) *Graduation date:* 22 March, 2010 *Supervisors:* Prof. Antti Räisänen and Pertti Vainikainen Research done at Finnish Defence Forces
Mika Koskiranta	Smart antenna application for wireless LAN systems (Adaptiivisen antennin soveltaminen WLAN-järjestelmissä) *Graduation date:* 22 March, 2010 *Supervisors:* Prof. Pertti Vainikainen Research done at Airspan networks (Finland)
Sampsa Lindroos	Wireless local area network in a residential building (Langaton lähiverkko asuintalossa)

Graduation date: 26 April, 2010
Supervisors: Prof. Pertti Vainikainen
Research done at Airspan networks (Finland)

Pirkko-Liisa Nurminen	Optimointimenetelmät suodatinsuunnittelussa (Optimization methods in filter design) *Graduation date:* 24 May, 2010 *Supervisor:* Prof. Martti Valtonen Research done at TKK Department of Radio Science and Engineering
Tuomas Pennanen	Antenni ilmanlaadun mittauslaitteessa (Antenna in air quality measuring instruments) *Supervisor:* Prof. Keijo Nikoskinen *Graduation date:* 24 May, 2010 Research done at Vaisala Oyj
Jarno Simola	Millimeter wave propagation measurements and modeling in hospital environment (Mm-aaltojen etenemismittaukset ja -mallinnus sairaalaympäristössä) *Graduation date:* 29 July, 2010 *Supervisor:* Prof. Pertti Vainikainen Research done at TKK Department of Radio Science and Engineering
Martta-Kaisa Olkkonen	Non-destructive RF moisture measurement of bio-material web (Biomateriaalirainan radiotaajuinen kosteudenmittaus ainetta rikkomatta) *Graduation date:* 14 June, 2010 *Supervisor:* Prof. Pertti Vainikainen Research done at TKK Department of Radio Science and Engineering
Tomi Mynttinen	A switchable double-line phase shifter and a metamaterial balun (Säädettävä kaksoislinjavaiheensiirrin ja metamateriaalibaluni) *Graduation date:* 14 June, 2010 *Supervisor:* Prof. Sergei Tretyakov Research done at TKK Department of Radio Science and Engineering
Antti Kivikero	Modelling circuit board containing embedded components (Haudattuja komponentteja sisältävän piirilevyn mallinnus) *Supervisor:* Prof. Martti Valtonen *Graduation date:* 14 June, 2010 Research done at TKK Department of Radio Science and Engineering
Katriina Veijola	Avaruuslaitteen testaus: SMOS-satelliitin kohinainjektioradiometri (The testing of space equipment: The noise injection radiometer of the SMOS satellite) *Supervisor:* Prof. Martti Hallikainen Research done at TKK Department of Radio Science and Engineering

8.4 Final Projects

Laura Martinez Navarrete	Modelling the user effect of mobile terminal antennas based on equivalent circuit – focus on frequency shifting *Supervisor:* Prof. (pro term) Tommi Laitinen Research done at TKK Department of Radio Science and Engineering
Xavier Gorroño Viñegla	Secchi 3000 LED BOX: Estimation of water quality using LEDs and a digital camera *Supervisor:* D.Sc. (Tech.) Sampsa Koponen Research done at TKK Department of Radio Science and Engineering
Bernhard Beuerle	Non-radiating waveguide with high permittivity dielectric and antennas based on it *Supervisor:* Prof. Antti Räisänen Research done at TKK Department of Radio Science and Engineering

9. Research

9.1 Highlights of RAD Research in 2010

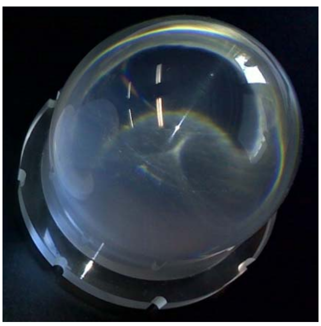
A brief summary of research groups of the RAD department follows. For more detailed information about the results, see the publications in Section 11.

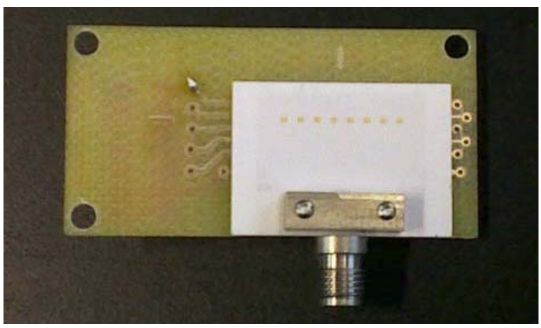
9.1.1 Millimeter Wave Techniques

Characterization, Modeling, and Applications of Nonlinear 2-Terminal Millimeter Wave Devices. Aalto RAD and MilliLab have continued ESA-related activities for the characterization of Schottky devices in standardized set-ups for IV, CV and S-parameters. A major new aspect was included in the characterization of Schottky diodes: measurements in a mixer test jig where the performance of different diodes can be assessed in mixer operation and under comparable conditions at 183 GHz. Among the results of this research is a new break-through in Schottky diode series resistance extraction. As a major improvement over the commonly used traditional method, the novel method takes holistically into account also important self-heating related effects in THz Schottky diodes having submicron junction dimensions.

Development of Schottky diode-based demonstrators has been continued. Demonstrator designs include a monolithic Schottky diode based frequency tripler which has been produced and successfully tested. Monolithically integrated frequency doubler and 340 GHz sub-harmonic mixer designs based on two different monolithic microwave integrated circuit (MMIC) Schottky diode technologies are under fabrication.

Lens Antenna with Feed Array for Beam Steering. A lens antenna with an integrated feed array can be used for beam-steering applications with high directivity. The conventional integrated lens types are extended hemispherical lens and elliptical lens. A Rexolite lens with optimized eccentricity was designed and tested at 77 GHz. The lens shape was optimized to achieve constant and high directivity over maximum beam-steering range. A LTCC feed array for the lens was designed and manufactured in VTT.

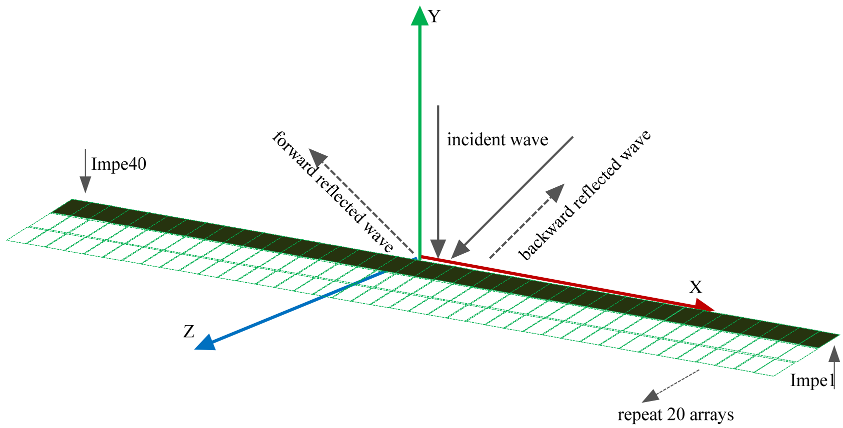




A photograph of the lens designed Rexolite lens with optimized eccentricity. A photograph of feed array with eight aperture coupled patch antennas on LTCC.

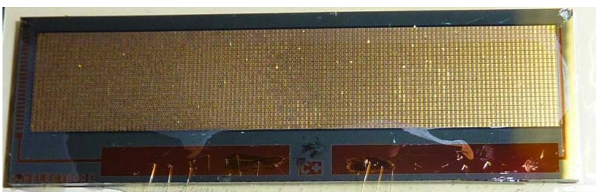
Millimeter Wave Beam Steering with a MEMS-Based High Impedance Surface. Beam steering with a MEMS-based high impedance surface has been studied in W band (80 GHz). The steering mechanism is based on the principle of phase gradient array. MEMS-based tuneable HIS is a periodic array of unit cells, with at least 5x5 cells, or much more depending on the application. The schematic design of the single unit cell of the MEMS-based HIS is shown below. The reflection phase property of this structure is analyzed by using a simplified model with appropriate boundary conditions. To keep the resonant frequency at the desired 80 GHz, the substrate height 110 µm and 75 µm were chosen as constant and the gap was varied according to each substrate separately.

MEMS tuneable HIS can be used for electronic reflective beam steering by inducing reconfigurable surface impedance via applying different bias voltage to different rows of elements of the MEMS varactors array. Since full-wave simulation of electrically large reflective surface with electrically small features of MEMS varactors is practically computationally impossible, a simplified model of a surface with 40 impedance strip lines of 0.35 x 0.35 mm^2 is used.



40 impedance elements in the open boundary conditions, normal and 45° off broadside incidence were excited to the surface.

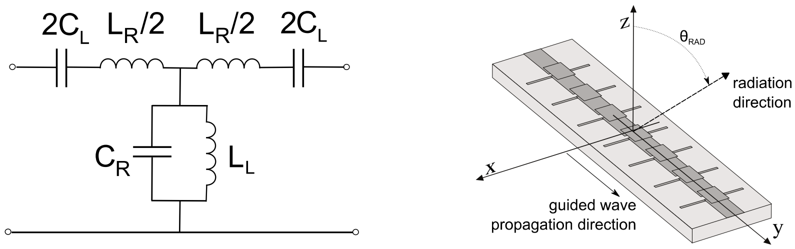
MEMS Tuneable High-Impedance Surface for an Analogue Type Phase Shifter. The phase shifter is based on a dielectric rod waveguide (DRW) with adjacent MEMS tuneable high-impedance surface (HIS) described in the previous section. Two samples of MEMS HIS has been fabricated by KTH (Royal Institute of Technology, Stockholm), each consisting of 120 x 24 MEMS varactors placed on a dielectric wafer with a ground plane.



Fabricated MEMS tuneable high-impedance surface.

The tapering part (6 mm) of the DRW with cross-section 0.5x1.0 mm2 made of Si was fixed with holders inside the WR-10 waveguides for measuring S-parameters. The sample was fixed adjacent to the DRW. The S-parameters of the phase shifter were measured applying to the MEMS HIS bias voltage, which was gradually changing from 0 V to 40 V.

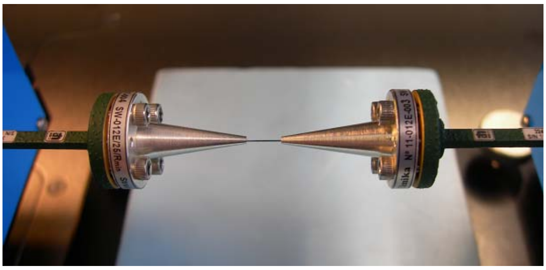
Frequency Fixed, Beam Steerable Leaky Wave Antenna Based on MEMS-Loaded Planar Transmission Lines. We aim to design, analyze and measure leaky-wave antenna (LWA) for automotive radar applications in mm-wave frequency range. The antenna designed is a periodical LWA. Design is based on balanced coupled right-left handed transmission line concept, also known as one dimensional metamaterial concept. The transmission line is periodically loaded with components dual to the transmission line parasitic parameters (per unit length series inductance L_R and parallel capacitance C_R, thus creating dispersive transmission line. The period of the loading is much smaller than the guided wavelength so that the condition for effective homogenization is fulfilled. A MEMS-capacitor is used as the loading capacitance C_L and a printed inductor is used as the parallel inductor L_L.



Transmission line unit cell model and LWA structure in Cartesian coordinates.

The planar transmission line LWA loaded with MEMS was tested with microstrip line (MS based cell), coplanar waveguide (CPW based cell), coupled strips (CS based cell) and capacitively grounded microstrip line. The MS structure was fabricated in cooperation with KTH, Sweden.

Dielectric Rod Waveguide Components. Nowadays DRW is one of the most efficient devices to transfer millimetre waves due to its low losses. Studies of dielectric rod waveguides made of high permittivity dielectric materials were continued in 110–170 GHz and 220–325 GHz frequency bands. A study for determination of DRW antenna phase centre at W band was finalized in cooperation with Universidad Politécnica de Madrid.

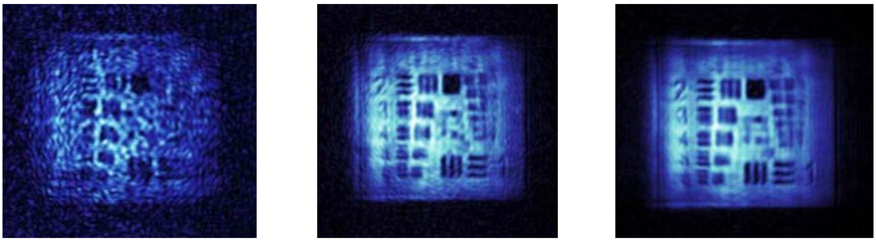


Measurement setup of a silicon rod waveguide at 220–325 GHz.

A novel type of bolometer power sensor for millimeter wave applications was created and tested. It consists of a metallic antenna-like structure on top of Si DRW. Under the incident mm-wave power the bolometer antenna-like structure is heated and the resistance of the structure is changing. By measuring the change of resistance one can detect and measure power applied to the power sensor. This power sensor can be integrated into a DRW and thereby it allows to measure amount of power inside the DRW. The power sensor has several advantages in comparison with other existing power sensors, for example it is capable of measuring high values of power in continuous mode (200 mW and higher), while typical value of burnout power for thermoelectrical heterostructure power sensors is 55 mW. This sensor is also extra wide band power sensor. It was tested in the frequency range of 95– 1011 GHz and it demonstrates good performance at all these frequencies.

Reconfigurable Millimetre-Wave Reflectarray for MMID and Imaging Applications. Reflectarray operating at 120 GHz is being developed. The 150-mm reflectarray is suitable for use in, e.g., millimeter-wave identification (MMID) or imaging application. The reflectarray will consist of approximately 3700 patch antennas coupled to micro-electro-mechanical-system (MEMS) based phase shifters, which are individually computer controlled. As a preliminary study perceiving the actively controlled system, static reflectarrays are designed and will be manufactured. Different test schemes will cover focusing the beam to a certain distance and to certain offset from boresight. The static reflectarray elements are based on grounded coplanar waveguide (GCPW) patch antennas coupled to a stub with length according to the desired phase shift.

Indirect Holographic Imaging: Image Quality Evaluation. In indirect holographic process, amplitude and phase of field reflected from target is recovered from amplitude of an interference pattern. Various image quality parameters are evaluated for 310-GHz imaging system. Estimates for the point spread function (PSF), SNR of the image, and for the noise equivalent reflectivity difference (NEΔR) are measured. SNR and NEΔR are evaluated also for different system noise levels in the imager. System noise level is artificially reduced, since laboratory equipment provides over-optimistic signal quality compared to realistic imager.



Millimeter-wave image of USAF 1951 with system SNR of 0 dB, 10 dB, and 20 dB.

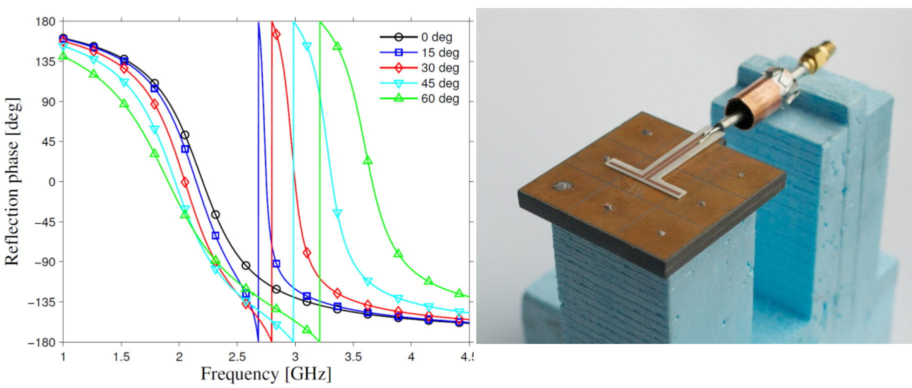
9.1.2 Advanced Artificial Materials and Smart Structures

The emphasis of this research team has been on investigations of new complex artificial materials and their applications. Here we briefly highlight some of the results.

We proposed ways to make metallic objects practically invisible to the electromagnetic radiation (in certain frequency bands) by employing various waveguiding structures that enable the electromagnetic wave either to go through an object or around an object. During this year, new designs have been proposed and numerically validated. These new designs allow easy and cheap manufacturing. Experimental tests are planned for the near future.

Huygens source antennas are electrically small antennas that radiate unidirectionally and in the ideal case have perfect polarization purity. The proposed antennas are composed of both electric and magnetic dipoles and the polarization of radiation is defined by the orientation and feeding of these dipoles. We have designed practical realizations of such antennas. The antennas have been studied analytically, numerically, and experimentally, confirming this concept for obtaining electrically small antennas with very useful radiation properties.

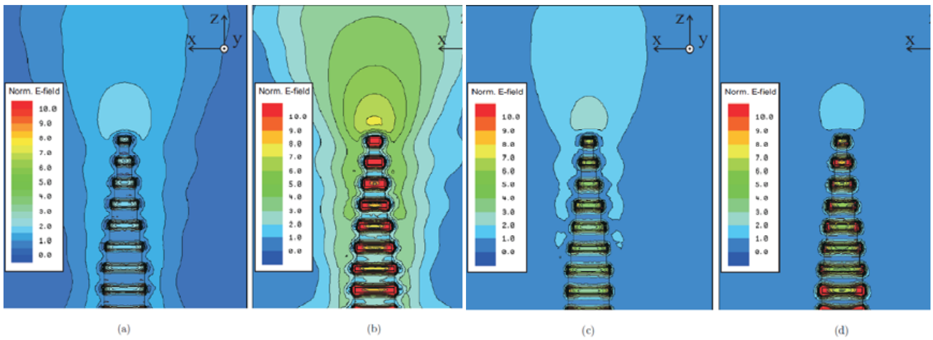
High-impedance surfaces (HISs) have been used as artificial magnetic conductors for low-profile dipole antennas. Usually, the desired operation has been designed using the phase-reflection simulations for normal incidence. We studied the properties of a mushroom-type HIS using reflection-phase calculations for oblique incidence and found two orthogonal resonant modes. An antenna based on a finite-sized HIS was designed to utilize both of these modes. The antenna was measured, and we found two separate modes with asymmetric radiation patterns. Both of the modes can be matched to 50-Ohm coaxial cables and good isolation levels between the ports are seen due to the orthogonality of the modes in the HIS.



Reflection-phase diagram for an infinite HIS with two resonance bands with the manufactured and measured dual-mode antenna.

Approaches of automated evaluation of electromagnetic material parameters have received a lot of attention in the literature. Among others, one method is to retrieve the material parameters from the reflection and transmission measurements of the sample material. Compared to other methods, this is a rather wide-band method, but suffers from an intrinsic limitation related to the electrical thickness of the measured material. In this work we propose a novel way to overcome this limitation. Although being based on the classical Nicolson-Ross-Weir (NRW) technique, the proposed extraction technique does not involve any branch seeking and is therefore capable of extracting material parameters from samples thicker than half a wavelength, a measure that would otherwise cause problems in the NRW extraction technique. The proposed derivative of the NRW extraction technique is then used to study the effect of thermal noise on the extracted material parameters.

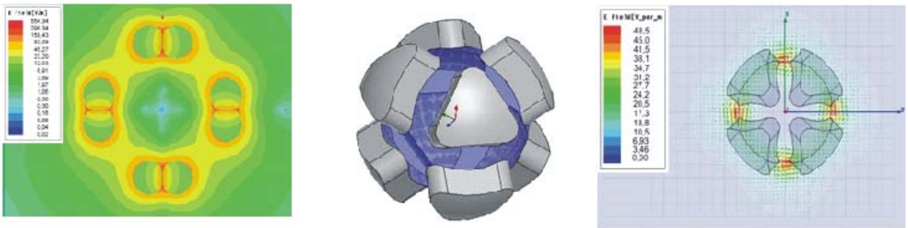
In 2010 we suggested and theoretically studied a tapered plasmonic nanostructure which connects the incident wave beam with a sub-wavelength spatial region where the field is locally enhanced in a broad frequency range or for different operation frequencies. This spatial region has a frequency stable location near the contour of the tapered structure. This results from a special waveguide mode which can also exist in the tapered structure. We foresee many possible applications for our structure from prospective near-field scanning optical microscopes to interconnect between conventional optical waveguides and prospective optical nanocircuits.



The normalized amplitude of the electric field at (a) 550THz, (b) 570THz, (c) 590THz, and (d) 610THz

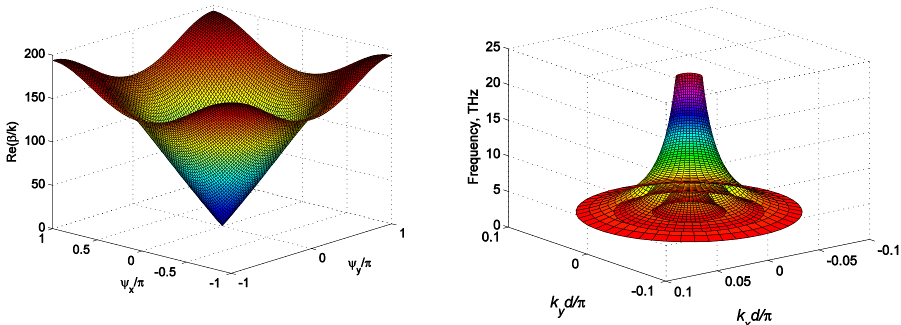
In 2003, it was shown that two parallel sheets with phase-conjugation boundary conditions for tangential fields on the two sides of the sheets have the property of the perfect lens. Perfect lens is a device which focuses the field of a point source into a point, that is, the perfect lens focuses both propagating and evanescent fields. In 2010, we developed first conceptual designs of structures that can potentially realize such performance. The suggested structures contain electrically and magnetically polarizable particles with appropriate nonlinear loads. The necessary balance between electric and magnetic polarizations can be ensured by using combinations of complex-shaped resonant particles, such as helices with symmetrically positioned nonlinear elements.

In 2010 we suggested and studied design solutions of metamaterials made of clusters of silver nanoparticles. These design solutions are modifications of the known effective rings formed by plasmonic nanospheres. Instead of nanospheres we suggest to use particles of different shapes, namely bi-spheres (dimers) and triangular nanoprisms. Nanoparticles are arranged into circular pattern on the dielectric core forming a raspberry-like magnetic nanocluster. We show that these two designs theoretically allow one to obtain negative effective permeability in the near infrared and visible range even taking into account real dissipative losses in silver. Our designs fit the conditions of the optical smallness of the individual magnetic scatterer which is necessary for the homogenization procedure. In our study we have utilized two independent methods of calculation of material parameters. The results will be used as a basis for our future studies directed towards practical creation of an isotropic doubly negative metamaterial operating in the visible range.



(left) - Spatial distribution of the amplitude of electric field at 369 THz for an effective plasmonic loop comprising four dimers; (center) - A cluster made of eight triangular nanoprisms on a dielectric core; (right) - Spatial distribution of the electric field vector at 400 THz for the cluster comprising eight triangular nanoprisms.

Electromagnetic modes, guided by infinitely long single-wall metallic carbon nanotubes (CNTs), forming two-dimensional periodic array, were studied theoretically. It was demonstrated that electromagnetic coupling dramatically raises the slow-wave factor of modes propagating in arrays compared to that observed in single carbon nanotubes. It was shown that the array of CNTs exhibit properties of indefinite media, i.e. media with different signs of components of the permittivity tensor.



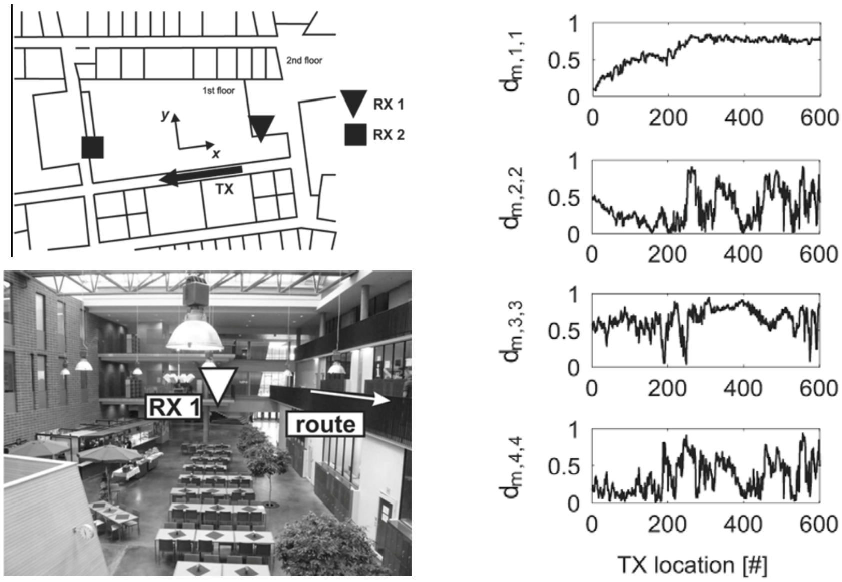
Slow-wave factor for waves, propagating along CNTs over the transversal wave vector plane (isofrequency surface), and the surface of dispersion for waves, propagating in a finite-thickness CNT slab.

We have shown that a finite-thickness slab of vertically standing metallic CNTs supports propagation of backward waves in ultra-broadband frequency range and by this reason can be referred to as a perfect planar metamaterial. Considerably low attenuation at terahertz frequencies is demonstrated. Transmission of a plane wave through a finite-thickness slab, which can be used as a terahertz polarizer, has been analyzed.

9.1.3 RF Applications in Mobile Communications and Industry

Multi-Link MIMO Channel Modeling Using a Geometry-Based Approach. A geometry-based stochastic channel model (GSCM) is a promising tool for reference channel models to develop next generation radio systems in to evaluate different candidates of transmission schemes. The work in our group is performed in co-operation with Lund University and has made an important addition to the GSCM to support multi-link simulations. This was achieved by the concept of common clusters, i.e., physical scatterers that produce multipath propagation for different links simultaneously.

The channel measurement and modeling results were inputted to the COST 2100 action to enhance the channel model. To validate the channel model, channel responses created by the new COST 2100 model were compared to channel measurements. Various evaluation metrics were used, such as delay and angular spreads, ergodic channel capacity in single-link scenarios, and inter-link correlation in multi-BS and multi-MS scenarios. In multi-user multiple-input multiple-output (MIMO) radio communications, correlation between links for different users results in degradation of sum rate capacity of the radio network.



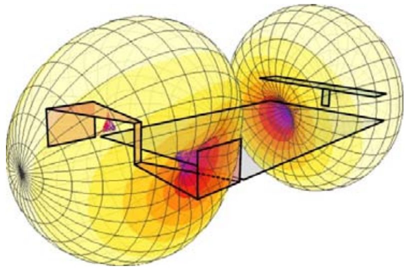
The interlink correlations on the mobile side are given based on calculating inner products of eigenvectors from two links to the fixed nodes. The interlink correlation indicated moderate to very high values even with large spatial separation of the fixed nodes.

Methodologies for Spherical Wave Modeling of Radio Channels. Recently, spherical wave modeling has gained attention in radio propagation channel modeling. In such modeling, the channel is treated as a spherical-mode to spherical-mode channel matrix, which relates each outward propagating spherical mode at the transmitter to those of the inward-propagating spherical modes at the receiver. Such a channel matrix allows a complete antenna de-embedding, and hence, once such a channel matrix is available, it can then be applied, for example, for UWB and MIMO performance studies of arbitrary antennas both at the transmitter and receiver without a need to repeat the measurement every time for a new transmit or receive antenna. In our work, we have investigated how linear scanners could be used for generating the channel matrices.

Statistical Channel Models for 60 GHz Radio Propagation in Hospital Environments. In this work a radio channel model for 60 GHz very-high-speed radio systems in hospital environments has been developed. Two possible applications of those systems were considered: real-time high definition video streaming for angiography and ultrasonic imaging. These applications require data rates of 1 Gb/s or even higher, which can be realized with 60 GHz radio systems. Channel modeling was based on extensive radio channel measurement campaigns in the angiography and ultrasonic inspection rooms in Yokohama City University Hospital, Japan. The measurements revealed that the power delay profile in the angiography and the ultrasonic imaging rooms is significantly different to existing standards and therefore novel model structures were developed for these hospital scenarios. The channel model is useful for the performance evaluation of the wireless systems in hospital environments.

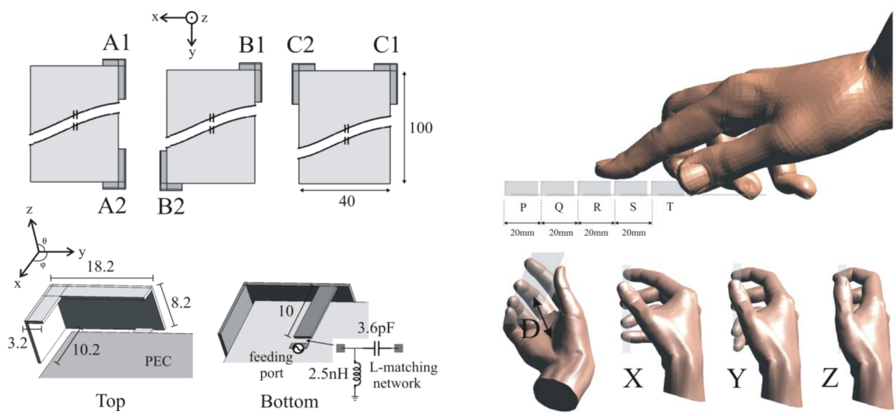
Broadband Equivalent Circuit Model for Mobile Terminal Antennas based on Capacitive Coupling Elements. During the design of antennas for mobile terminals, the interactions of different conductive and dielectric antenna parts with each other and with the user holding the device are so complex that EM simulation tools are typically used evaluate and optimize the performance of new designs. The theory of wavemodes simplifies the characterization of the electromagnetic interaction between the different radiating antenna parts. The proposed resulting equivalent circuit model improves the general understanding of the operation of the antenna structure.

Improving Isolation between Mobile Terminal Antennas around 900 MHz. Modern mobile terminals operate in a number of different radio systems and thus require multi-band functionality and multiple antennas. The number of antennas in mobile terminals will further increase with the use of MIMO techniques. Since the space reserved for the antennas is not growing, obtaining sufficient isolation between the antennas is challenging, especially below 1 GHz. A novel method improving the isolation between antenna elements on a mobile terminal was developed for the 900-MHz frequency band. It was shown that the proposed structures can achieve up to 100 dB port-to-port isolation.



Novel antenna structure with a capacitive coupling element (CCE) and a bow-tie antenna. The unbalanced (CCE) and balanced (bow-tie) antenna elements have almost orthogonal radiation patterns.

Reduction of the Effect of the User's Hand on Antenna Structures in Mobile Terminals. The presence of the hand of the user of a mobile terminal has been shown to significantly deteriorate the performance of the antennas. It was studied how to at least partially compensate this effect by using antenna selection. Both the effect of only the index finger, which is often the main reason for the deterioration, and that of different grips of the hand were studied. Measurements around 2 GHz show that the total efficiency can be improved by 2–6 dB with the antenna selection technique.



Coupling element based dual-antenna structures with different configurations with a multivariable study on hand effects.

Linear 5-Element Antenna Array for Beam Steering Applications at 60 GHz. To obtain high-data-rate links indoors at 60 GHz, beam steering is one solution to overcome the high path loss. A linear 5-element antenna array with phase shifters was designed in co-operation with Nice University using membrane technology. With the membrane process mm-wave antennas with high radiation efficiency and good radiation characteristics can be realized. The same process can be used to manufacture phase shifters based on MEMS switches. The simulated maximum gain of the developed 5-monopole antenna array is 9.0 dBi and the radiation efficiency is 87 %. Five equally spaced monopole antennas, each with a gain of 3.2 dBi, form the array. The matching of the antenna elements is better than -13.5 dB over the frequency range 57-64 GHz, The results show that the membrane technology is a good option for implementing a beam steering antenna system for 60 GHz communications applications.

Moisture Measurements of Bio-Material Web Using an RF Resonator Sensor. The objective of the project was to determine the moisture of a bio material web (sludge from a paper factory) non-destructively using a resonator sensor. The determination of the moisture content is based on the resonant frequency shift of the resonator due to change of the permittivity of the material inserted in the resonator. The comparison of the measurement results with reference moisture values obtained by oven drying indicate that the residual standard deviation in determining the amount of water per area thickness is about 10 %.

Moisture measurement setup in the factory measurements

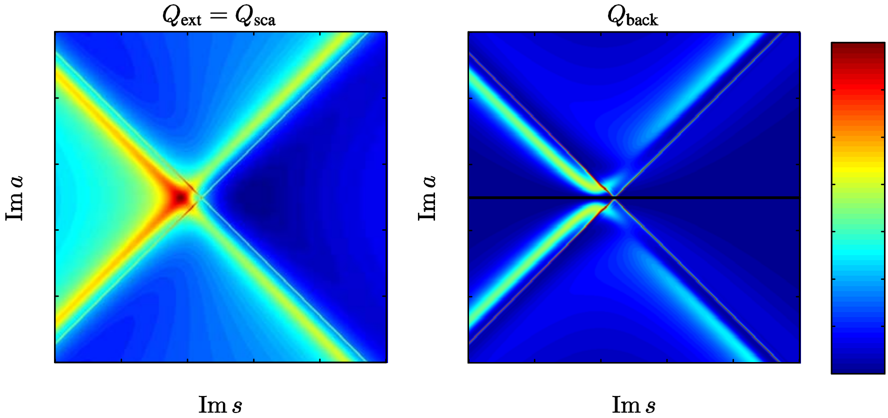
Multi-Probe Systems, MIMO over-the-air Testing and Probe-Corrected Spherical Near-Field Antenna Measurements. Multiple probe systems for fast testing of antennas were investigated. A method for fully compensating the reflections from the neighboring probes in a multi-probe system was developed. This method is based on an over-the-air calibration of a multi-probe system using a known calibration antenna and subsequent measurement of the pattern of the antenna under test. This compensation is analogous to the traditional probe correction in spherical near-field antenna measurements with a single probe. Probe-corrected spherical near-field antenna measurements were developed together with Technical University of Denmark. Here methodology for probe-corrected spherical near-field antenna measurements with a specific double phi-step theta-scanning scheme was developed.

Investigations of Fuel Cells under the Exposure of Electromagnetic Fields. It was examined whether the efficiency of fuel cells could be enhanced by exposing them to the influence of electromagnetic fields. Electrical properties of liquids in the fuel cell were measured to know how the electromagnetic fields propagate in the fuel cell. The output power of the fuel cell was measured without external electromagnetic field and with the external electromagnetic field over the frequency range from 50 MHz to 5 GHz to find the frequencies at which the efficiency enhancement might occur. The results from the first series of measurements did not show any enhancement of the efficiency while noting that the measurements were subject to several uncertainties.

9.1.4 Wave-Material Interaction

Fundamentals of Electromagnetics. The theoretical foundations of electromagnetics and solution principles of electromagnetic field problems have formed a long tradition in the laboratories that now form the RAD Department. In the group, this tradition is carried on. This research direction includes, among other things, general principles and advanced methods to solve canonical electromagnetic problems, like image theories, field decomposition principles, and duality and symmetry principles applied to the quantitative description of material responses. Mathematical formalisms are developed with which complex electromagnetic problems can be approached in concise and effective manner. These include dyadic algebra and differential forms. New boundary conditions and surface structures have been suggested (like so-called PEMC and DB boundaries) that have turned out to be important in modeling wave interaction with complex materials.

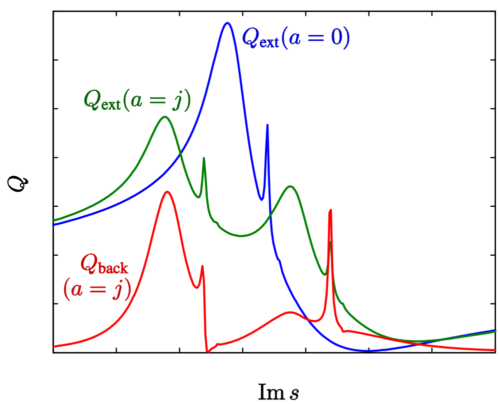
In particular, efforts have been put on the study, analysis, and development boundary conditions that are defined by the normal components of the electric and magnetic fields. The classical way of forcing boundary conditions on fields is to restrict the freedom of the tangential components of either electric or magnetic fields, or both. In contrast, conditions that deal with the normal components have been shown to form a class that can be generalized from the DB boundary condition (in which the normal components of both the electric and magnetic flux density vanish at the boundary). By treating the normal derivatives of the normal components instead of the fluxes themselves we arrive at so-called D´B´ boundary conditions. Further generalizations that display interesting properties include conditions which involve linear combinations of the normal flux density and its normal derivative.



The so-called mixed-impedance boundary conditions mean that such a boundary acts differently for TE and TM-polarized waves—an example being the DB boundary. By representing the two surface impedances using self-dual and anti-self-dual parameters, the reflection and scattering behavior of the boundary can be characterized in a concise manner.

Dielectric Modeling of Random Materials. Homogenization theories and models for dielectric mixtures are developed, classified, characterized, and tested in the group. These are also applied to various random and ordered media, both natural and composite materials. In this research direction, the effect of microgeometry on the macroscopic properties (magnitude of the effective polarization, losses, anisotropy, artificial magnetism, etc.) has a strong role. Also the inherent capability of classical mixing rules (Maxwell Garnett formula, Bruggeman formula, etc.) to predict unexpected phenomena, like enhanced polarization or percolative behavior, is under study. Mixing rules are also tested against numerical simulations using both lattice structures and Monte-Carlo-generated random samples. In these computations, both in - house and commercial codes (particularly COMSOL Multiphysics and CST Microwave Studio) are being used. These computations are also extended to metamaterials type heterogeneous mixtures involving negative-permittivity constituents.

Interplay Between Geometry and Matter and Complex Material Responses. The effect of particle shape and boundary geometry on the polarizability properties of small inclusions have been charted systematically. Both the permittivity and shape of the particles contribute to the solution of the electrostatic problem from which the macroscopic response parameters can be extracted. Especially for the negative-permittivity region, the resonance structure of the polarizability function contains important information which can be used in several applications within the field of plasmonics. In particular, shapes have been studied that involve various combinations of spherical boundaries in two and three dimensions. In particular, the two-dimensional case of cylinders with semicircular cross section was given particular attention.

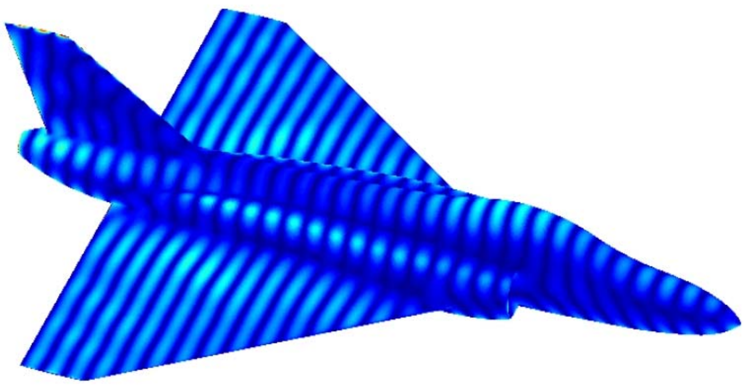


The extinction and backscattering cross sections of a sphere with mixed-impedance boundary condition display very interesting and narrow resonance peaks when the self-dual surface impedance parameter is varied.

Electrical Engineering Education Research. The Electrical Engineering Education Research Group at RAD is interested in learning and teaching issues in electrical engineering. The main objective is to find new approaches understanding the learning environment, and to understand various factors affecting the quality of learning. The focus of the research group is on basic students, as well as on graduate adult electrical engineers. Two doctoral theses are in progress, which are related to electrical engineers' perceptions on learning, expertise and scientific thinking, and to the evaluation of engineering students' proficiency in electromagnetics. The first thesis primarily examines the learning of electrical engineering and its connection to work life. The focus of the second thesis is on studying what factors influence the development of engineering students' mathematical proficiency when learning electromagnetics (EM) and what factors prevent students from building their academic and scientific expertise.

9.1.5 Computational Electromagnetics

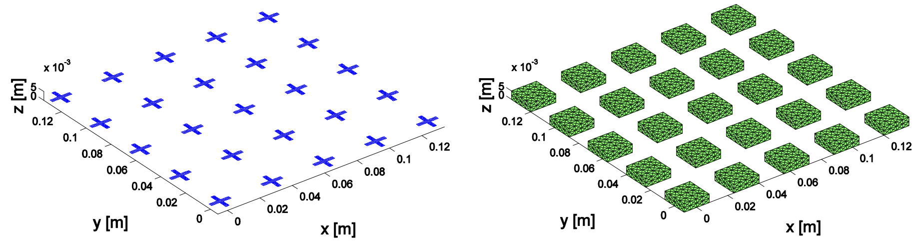
Multilevel Fast Multipole Algorithm. In integral equation methods (the method of moments, MoM) one of the main research topics has been the development of techniques that can be utilized to efficiently solve large and complex real-life problems on a broad frequency range. We have continued the work with the broadband multilevel fast multipole algorithm (MLFMA). The method developed earlier for scalar acoustic scattering problems was extended for vectorial electromagnetic problems. It is based on a hybrid technique where at small division cubes the receiving and radiating field patterns are expressed with spherical harmonics expansions and the in-to-out and out-to-in translations are performed with inhomogeneous planewave expansion. On large cubes the traditional planewave based MLFMA is used. The developed algorithm allows us to efficiently and accurately solve very large electromagnetic scattering problems.



Distribution of the induced electric current on the surface of an aircraft computed with MLFMA. The surface of the aircraft consists of more than one million triangles.

Domain Decomposition Method Combining Surface Equivalence Principle and Macro Basis Functions. Electromagnetic scattering by large and complex structures, such as electromagnetic band gaps, frequency selective surfaces, metamaterials, antenna arrays, etc. have received a lot of interest lately. In the conventional integral equation and finite element approaches the structure is first divided into simple elements and then the unknown quantities, currents or fields, are expanded with basis functions defined on these elements. As the size of the structure gets larger, the number of elements required to sufficiently model the unknown and the structure details increases, eventually leading to the problem of solving huge, possibly very ill-conditioned, linear systems. This may be a very challenging task even with the most powerful computers and efficient fast algorithms.

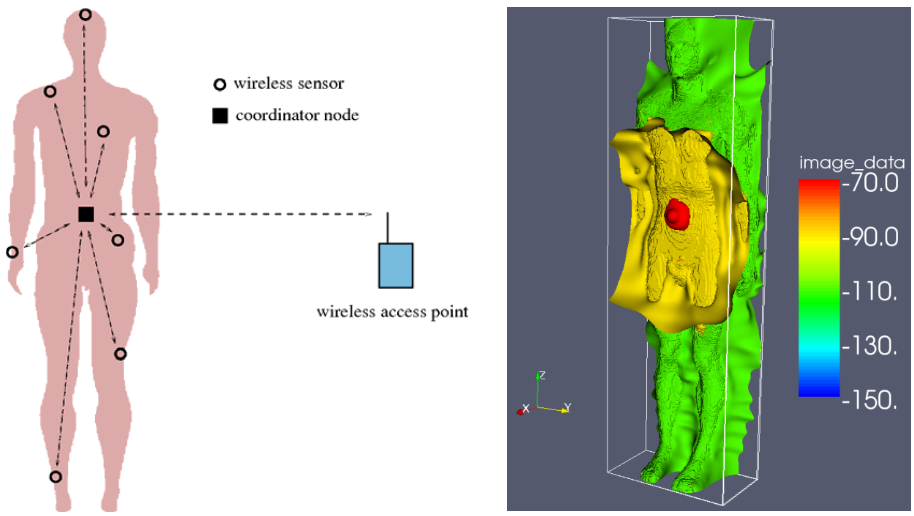
We have developed domain decomposition methods (DDM) based on the surface equivalence (Huygens) principle and the method of moments (MoM), called equivalence principle algorithm (EPA), for the solution of large scale problems. The basic idea in a DDM is to divide a large and complex problem into smaller and simpler subproblems that can be solved independently. This essentially isolates the solution of one region from another, in many cases significantly improves the matrix conditioning and allows solution of large problems with modest computer resources. In order to further reduce the number of unknowns and the solution time, EPA was combined with the characteristic basis function method.



Formulation of a scattering by a frequency selective surface with EPA. The original structure (left) is replaced by the EPA model with virtual surfaces.

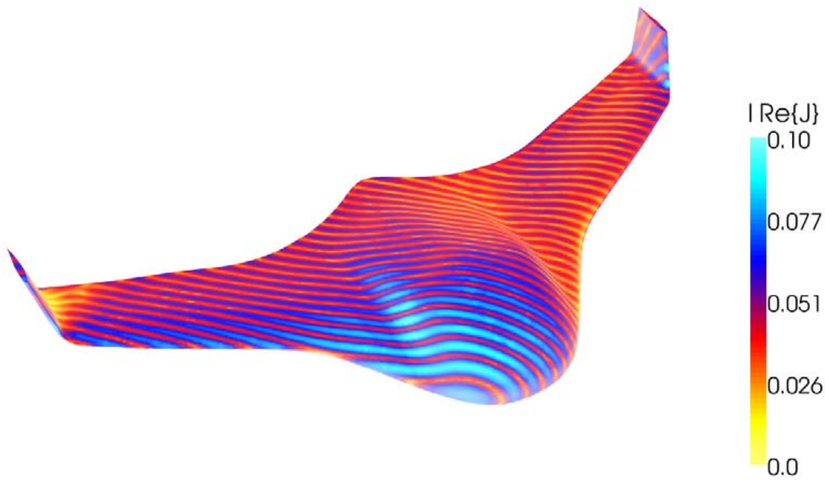
Calderon Preconditioner for Composite Structures. Most of the traditional surface integral equation formulations produce ill-conditioned matrices for fine mesh densities and at low frequencies, and lead to problems with the iterative solution of the matrix equation. Recently, so called Calderon preconditioning, has been studied intensively to remove the low-frequency and dens mesh problems. The strategy in Calderon preconditioning is different than in conventional (numerical) preconditioners. It is based on the self-regularizing property of the electric field integral operator and Calderon integral identities.

We have extended the Calderon preconditioner for piecewise homogeneous penetrable and composite metallic and dielectric objects. The method is based on the electric current formulation (ECF). In the ECF the ill-conditioned electric field and the well-conditioned magnetic field integral operators appear in separate equations, making the use of the preconditioner much easier than in the conventional so called field formulations. In particular, this property, together with the fact that in ECF the currents on the opposite sides of an interface are not combined, allows us to straightforwardly generalize the Calderon preconditioner for composite objects with junctions.



WBAN (Wireless Body Area Network) schematic with logarithmic amplitude of the electric field Ex for a test simulation. A Hertzian dipole source is located at the navel (f=2450 MHz).

Computational Research on Body Area Networks. Wireless body area network (WBAN) is a promising technology for future health care, for instance. WBAN is essentially a short-range network consisting of low weight, small and low power devices which gather or deliver information (sensors/actuators) and communicate with each other and with the central node which may locate on the body or nearby. In a Finnish-Japanese co-project, FINJAP2, these future networks are studied by a computational method that is based on parallel FDTD and anatomical human-body models. In-house codes are used, and the RF-field simulations are run in a supercluster in CSC. The aim is to study, for instance, path loss in different WBAN scenarios (transmitter/receiver locations, frequencies, etc). Another goal is to model the effect of human movement on path loss.



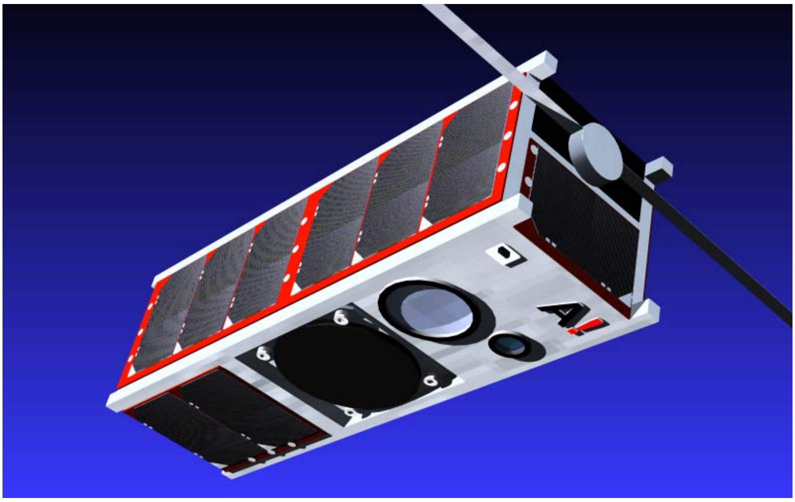
Electromagnetic scattering by a conducting object can be calculated from the information about the equivalent currents on the surface.

9.1.6 Remote Sensing and Space Technology

Aalto-1 Student Satellite. The Department of Radio Science and Engineering initiated in 2010 an Earth Observation nanosatellite project in order to demonstrate latest Finnish technology and promote technical education, especially to motivate students to choose their careers within space technology and Earth Observation. The Aalto-1 satellite will be mainly built by students as project assignments and thesis work. The satellite project is supported by several other departments of Aalto University and a network of national partners. The latest sensor payload technology is brought to the project by VTT Technical Research Centre of Finland, which is developing the main Earth Observation payload for the satellite. Secondary payloads are developed by a consortium including the Finnish Meteorological Institute, Department of Physics of University of Helsinki, Department of Physics and Astronomy of University of Turku, Aboa Space Research Ltd., Oxford Instruments Analytical Ltd. and other companies.

The 3-4 kg and 10 x 10 x 34 cm^3 sized Aalto-1 satellite is based on the CubeSat concept. The main scientific goal of the mission is to demonstrate the feasibility of MEMS Fabry-Perot spectrometers for space applications. Other innovative payloads include a novel radiation detector for charged particles and an electrostatic plasma brake system, which is a novel de-orbiting device, to be demonstrated for the first time in space. The satellite platform and ground segment are designed and integrated by Aalto University. The platform has a full 3-axis attitude control and maneuver system, an efficient downlink for data transfer, a constant telemetry connection, and bus for several subsystems. The satellite is designed for a sun-synchronous midday/midnight orbit.

The satellite uses UHF/VHF and S-band amateur radio frequencies for communication and it will be accessible through international amateur satellite communication network GENSO. The ground station is located on Aalto University campus, but cooperation is planned with several universities in order to use their respective facilities. The launch of Aalto-1 is scheduled for late 2013.



A sketch of Aalto-1 satellite.

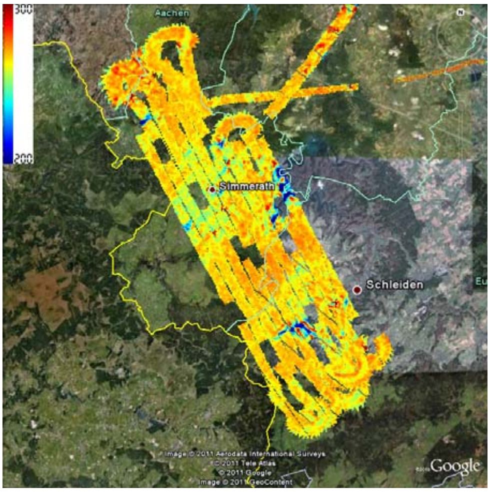
SMOS-Related Research. The ESA SMOS (Soil Moisture Ocean Salinity) space-borne radiometer, launched 2 November 2009, operates within the protected radio astronomy band 1.400–1.427 GHz and measures thermal noise emitted by land and ocean surfaces. NASA's future space-borne remote sensing missions Aquarius (launch scheduled for 2011) and SMAP (launch scheduled for late 2014) will also utilize L-band radiometry to monitor ocean salinity and soil moisture and freeze/thaw state.

ESA AO Project NORA. The RAD Space Technology Group leads the national SMOS - related Announcement of Opportunity project "SMOS Calibration and Validation Activities in Northern Area" (NORA) working together with the Finnish Meteorological Institute and Finnish Environment Institute in order to further develop methods to retrieve soil moisture and sea surface salinity in northern areas, where major obstacles in achieving good accuracy are forest canopies and pixels with variable land-cover types, and cold and low-salinity sea water, respectively.

Year 2010 was the first complete year for SMOS to measure global brightness temperatures, and the Space Technology Group has established temporal time series from SMOS data over various target areas presently considered for calibration and validation purposes, including the Antarctica, Pacific Ocean, Atlantic Ocean and the desert of Sahara. Issues such as thermal stability, radiometric resolution, and overall performance of the SMOS Reference Radiometers have been addressed and conclusions presented to ESA in order to utilize them in the optimization of the performance of the whole mission.

ESA 2010 Cal/Val Campaign. In May-June 2010 the Space Technology Group participated in a SMOS calibration campaign with the airborne HUT-2D radiometer system in the frame of ESA SMOS Calibration and Validation activities. Flying measurement flights concurrent with SMOS overpasses, radiometer data were acquired over selected soil moisture test sites in Denmark and Central/Southern Germany, all recognized as major soil moisture calibration and validation sites for the SMOS mission.

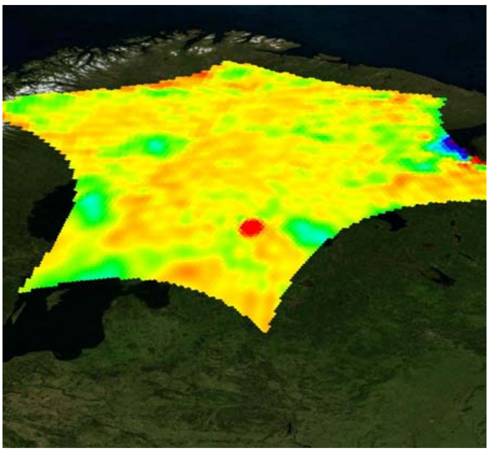
At each test site an area corresponding to SMOS ground resolution (diameter ~44 km) was validated by means of (a) measurements of a soil moisture network with 30 stations distributed throughout the area, and (b) the airborne campaign with snapshots concurrent with ground measurements in three selected patches of different land cover types.



A brightness temperature mosaic measured by HUT-2D over the Rur-Erft Catchment area, Germany, June 2010. Brightness temperatures are color-coded.

<u>TEKES RFI Project.</u> In 2009 the RAD Space Technology group initiated a 3-year project entitled Detection and Classification of Radio Frequency Interference in order to study the appearance and detection of RFI in the radiometer data collected by interferometric radiometers, such as the space-borne MIRAS onboard the SMOS satellite and the airborne HUT-2D onboard the RAD research aircraft.

The SMOS satellite has observed numerous man-made RFI sources, located especially in Europe, Middle-East and Asia. In April 2010 the HUT-2D sensor was utilized to locate a strong RFI source in Joutseno, southeastern Finland. The RFI source was subsequently removed by authorities. In addition, the HUT-2D has detected RFI in both Finland and Central Europe.



An image of a SMOS snapshot with corruption caused by RFI visible in the center. The source was located with the HUT-2D sensor and later removed by authorities.

Design of Advanced High-Frequency Radar System. The Strategic Centres for Science, Technology and Innovation (SHOK), recently established in Finland, are new public-private partnerships for speeding up innovation processes. A consortium led by the Finnish Meteorological Institute is developing an advanced high frequency (14-96 GHz) radar system for operation in various application areas as part of the Measurement, Monitoring and Environmental Assessment (MMEA) research program. It is funded jointly by TEKES, participating research institutes and companies. The Space Technology Group is a consortium member along with University of Helsinki, DA-Design Ltd., Harp Technologies Ltd., Vaisala, Eigenor Corp., Aerial Ltd., and Space Systems Finland. The development is currently in system design phase. Activities at Aalto University include radar system design, RF design, mechanical design, system integration, instrument measurement planning and implementation. The main aim is to demonstrate new radar technology using cost-effective solid state components. The instrument under development will be the first dual-polarized all solid-state Doppler weather radar operating simultaneously at Ku-, Ka-, and W-bands.

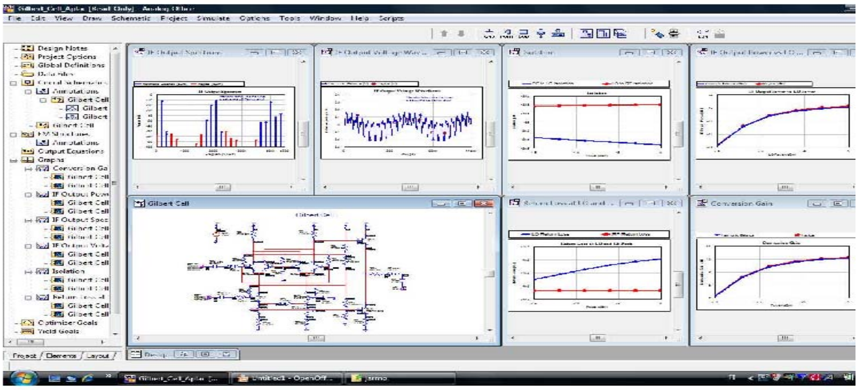
Electromagnetic Properties of a Melting Hydrometeor. In radar measurements the melting layer can be distinguished as an enhanced radar reflectivity factor, hence it is also called bright band, and a rapid increase of particle fall speed. The bright band is considered important mainly as an error source in precipitation estimates and as a cause of signal attenuation on satellite links. Typically the electromagnetic scattering characteristics of melting hydrometeors in the layer are modeled with analytical solution of Mie or with the T-matrix method. Since these methods are for homogeneous particles, an effective media approximation (EMA) must be applied and with approximation the constitute structure of the melting particle is no longer observable. In our study we model the nonuniform distribution of water in the melting particle and compute the scattering characteristics with the volume integral equation method. As these results are combined with a microphysical melting layer model, also the polarimetric radar observables of the layer can be distinguished, which is presently of interest as the weather radar networks all around the world are renewed with polarimetric radars.

Operational Ice Product for Arctic Sea. In co-operation with Finnish Meteorological Institute, the Space Technology Group is involved in creating an operational and multi-source product for the Arctic Sea area. We have studied the incidence angle dependence of backscattering coefficient for different ice types exploiting Envisat ASAR images. In the identification of new ice formation areas (polynyas), AMSR-E radiometer data together with MODIS surface temperature data and HIRLAM air temperature data are used. The temperature difference between surface and air defines a threshold value for the calculation of radiometric parameters, e.g. a polarization ratio of a single frequency channel or a gradient of two frequency channels.

New Water Quality Measurement Device. The objective of the Secchi3000 part of the TEKES-funded JVP project (Lake Water quality Service) was to develop a cheap (price less than 20-30 Euro) device for in situ estimation of water quality. Together with the Finnish Environment Institute (SYKE) RAD designed a container prototype where water sample is placed. The container includes black and white plates at three depths and due to the attenuation of light in water the plates appear to have different colors when viewed from above. By taking a digital photo of the plates and analyzing the color differences it is possible to estimate the attenuation at Red, Green and Blue wavelengths, and from these to estimate water quality parameters such as Secchi depth (Z_{SD}), turbidity, suspended matter (TSM) and humic matter (CDOM). Consumer level digital cameras were selected as the sensor element of the device, since they are very common and included in most mobile phones.

9.1.7 Circuit Theory, Simulation, and Modeling

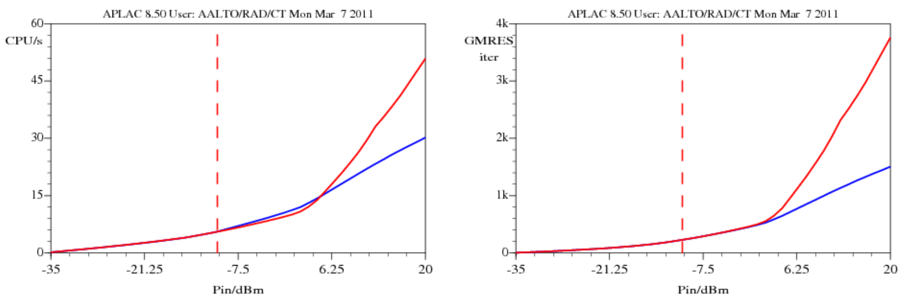
The circuit theory research team has over 30 years tradition in developing circuit simulation algorithms and models for active and passive circuit components. As a fruit of the work a circuit design software package APLAC has been developed. A start-up company (Aplac Solutions Oy) was founded in 1998 and since 2005 APLAC has been integrated to the products of Applied Wave Research Corporation (AWR). Gradually APLAC (http://web.awrcorp.com) has grown to a world-class state-of-the-art foundry-approved circuit design tool fulfilling the needs of modern RFIC design, model-order reduction (MOR) of interconnects, MEMS circuit modeling, and RF measurements. The Circuit Theory Research Team has continuous active role in developing the algorithms and models of APLAC. This is enabled by external funding from AWR and TEKES. From the university's point of view this is rewarding because the results of the circuit theory group's scientific work are implemented in APLAC and are thus immediately used by thousands of designers and researchers all over the world in the industry, research institutes, and academia.



View of the AWR design environment with APLAC simulations.

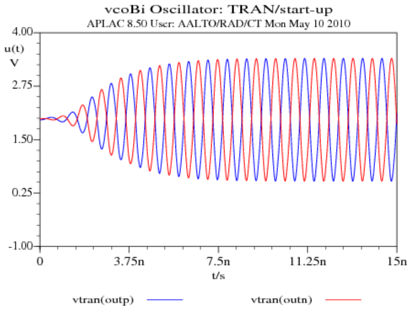
Harmonic Balance Analysis. Harmonic balance (HB) is an analysis method that simulates a circuit under single- or multi-tone excitations. Nonlinear noise analysis is based on HB analysis and takes into account mixing phenomena from one frequency to another. Automatic usage of iterative solver (GMRES) instead of direct LU-based solver results in both faster simulation and smaller memory consumption for large RF circuits. The larger is the circuit the bigger is the improvement.

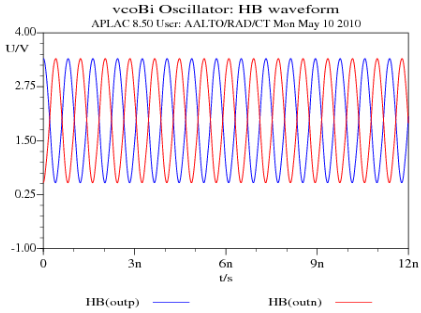
During ICESTARS research project (EU/ICT/FP7/214911, (http://www.icestars.eu) HB method was improved to be more robust and adaptive. One example of the adaptivity is the possibility to change the preconditioner needed by the GMRES iterative solver: when the input power level increases, the diagonal-block-based preconditioner is no longer adequate, and is therefore changed to more complex time-domain preconditioner to better adapt to the increased nonlinearity. Figures below show cumulative CPU-time and the number of GMRES iterations with the new algorithm (blue solid line), the reference simulations (red solid line) used the simple diagonal-block-preconditioner at all power levels. Vertical dashed red line indicates the power level for switching the type of the preconditioner.



CPU-time and GMRES iterations as a function of the power level.

Oscillator Analysis. Another case showing robustness and adaptivity is the HB based oscillator analysis. Traditionally oscillator simulation has been relatively easy for transient simulation but difficult for HB method. Usually we need to use HB as we want to use more accurate frequency-domain linear models and/or compute phase noise of an oscillator -- both of these are easy to handle using HB. In the new approach we first run an initial transient and extract improved initial estimates for the oscillation frequency and output voltage amplitude. Two methods for extracting frequency and amplitude have been developed: one is based on FFT and the other is based on detection of zero crossings, which is one form of Poincarè method. The figures below show the transient and HB waveforms of a VCO circuit.





Transient and HB waveforms of a VCO oscillator.

STONGA Project. Simulation Tool Offering Next Generation Analysis (STONGA) project partner is AWR-APLAC Oy, and the project is partially funded by TEKES. The projects focus areas are listed below.

Graphics Processing Unit Utilization in Circuit Simulation. Today graphics processing units (GPU) of common desktop computers have a capacity for computing massive amounts of data in parallel. GPU's computing capacity can be utilized also for accelerating general-purpose computation in applications, such as circuit simulators, which evaluate large data quantities concurrently. Hence, possibilities of improving performance of APLAC circuit simulator with GPU computation have been researched as a part of STONGA project. As a result, the development of diode component model evaluation using GPU has been started. Later on, GPU support is due to be extended also to BSIM3 transistor model evaluation.

Efficient Analysis Methods. Improve and develop new simulation algorithms that can benefit from multi-core CPUs, and are suitable for simulating large-scale circuits. One application area is to develop multi-threaded sparse matrix solver, which can be used by various analysis methods, such as DC, transient and HB.

Behavioral Modeling. Continue development of PolyHarmonic Distortion (PHD) models for multi-tone and for envelope simulation methods.

Circuit and Field Cosimulation. As signal frequencies grow and circuit sizes shrink, simulating circuits increasingly requires the use of electromagnetic field simulators. Generating complex meaningful signals and realistic termination loads in field simulators for accurate simulations is challenging. Cosimulation, wherein a circuit simulator is used to produce the desired signals or a load termination in a field simulation, is an effective approach to tackle this task.

The finite-difference time-domain (FDTD) method for simulating electromagnetic fields lends itself well for lumped element cosimulation. Transient analysis of a circuit simulator is readily combined with the FDTD method, being itself a transient analysis. Work carried out in the last year has resulted in the development of a new method, or interface, for the two simulator types to communicate and exchange data. The cosimulation approach has been verified with numerical experiments and comparisons with simulation results from a circuit simulator. However, experiment results show that the interface seems to produce diverging results in some simulation set ups and requires further study. In particular, investigating the stability behavior of this method is thought to provide a clue to the reason for the diverging results.

Model-Order Reduction. Model-order reduction (MOR) is a method used to speed up computer simulations of large systems. In circuit simulation, the typical starting point for MOR is a large RLC circuit which models the circuit interconnects between transistors (e.g., clock distribution network) or the effects of IC packaging (e.g., electromagnetic coupling between IC pins). The goal of MOR is to approximate (the poles of) the original system matrices such that the large RLC circuit can be replaced by a much smaller one.

In 2010, we finalized the development of a new Partitioning-Based Realizable Model-Order Reduction Method for RLC circuits (PartMOR), which is based on partitioning the original RLC circuit into small sections that can be accurately approximated with simple low&-order RLC macromodels. Also, we extended PartMOR such that it can efficiently handle mutual inductances and the possible singularities of the circuit matrix. Finally, we carried out research on hierarchical Krylov-subspace-based MOR methods.

Behavioral Modeling of RF Power Amplifiers. Modern wireless communication circuits and systems are too complicated to be fully simulated at the transistor level. The goal of automated behavioral modeling (ABM) is to enable the hierarchical nonlinear simulation of such circuits and systems. The idea of ABM is to start from nonlinear measurements or transistor-level simulations of a complex circuit block, generate a fast-to-simulate, yet accurate enough, behavioral model for it, and use the model for simulation at a higher level of abstraction.

In 2010, the research work started in 2009 was continued, resulting in commercialization of an ABM tool, which can be used for creating HB-simulation-based, nonlinear, and memory-effect-aware power-amplifier models for discrete-time envelope-domain system simulation. The ABM tool was jointly developed with the R&D group of AWR-APLAC Corporation, thanks to the second-year funding from the Academy of Finland ("Mobility in Working Life"). The ABM tool is extensively based on APLAC functionality and time-delay neural networks.

9.2 MilliLab

MilliLab is the name of the *ESA External Laboratory on Millimetre Wave Technology*, in the form of a joint laboratory between Technical Research Centre of Finland (VTT) and TKK (currently from 1.1.2010 Aalto University School of Science and Technology). MilliLab is governed by a Board constituting of members appointed from VTT, Aalto University, and industry. The Chairman of the Board is Professor Antti Räisänen from Aalto University. The Director of MilliLab is Research Professor Docent Arttu Luukanen from VTT. The main purpose of MilliLab is to offer support to European space industry in the field of millimetre wave technology. However, also other than space technology companies and organizations are as well welcome to use MilliLab’s expertise. MilliLab supplies services at millimetre wave frequencies in device modeling, device characterization, measurement and testing, and research and development.

The parent organizations of MilliLab have in their research groups major players in Finland and also internationally in fields of microwave and millimetre wave technology. Under the common institute MilliLab, this all has been strengthened in millimetre wave engineering and research, and also in education in contributing to several doctoral dissertations. All the resources and co - operative assets of these organizations are readily available via MilliLab. The total number of research personnel with millimetre wave experience is about 15. MilliLab’s major achievements in recent years have included participation in receiver development for the Planck satellite mission and demonstration of the hologram CATR method up to 650 GHz as a solution to the measurement problem of large reflector antennas. Lately, THz imaging has emerged as a major new field of interest and growing expertise.

MilliLab’s contact person at the university is MilliLab Senior Scientist. MilliLab Senior Scientist participates also in the education and teaching activities in the Department of Radio Science and Engineering where he is positioned as a researcher with teaching responsibilities. Director and Contracts Officer of MilliLab are positioned at VTT. Other MilliLab personnel are involved on research project basis.

9.3 SMARAD

In 2001 the Academy of Finland appointed SMARAD with the name Smart and Novel Radios Research Unit as one of the centers of excellence in research for the period 2002–2007. In 2006 the Academy announced its decision that the renewed SMARAD (Centre of Excellence in Smart Radios and Wireless Research) was appointed a Centre of Excellence for years 2008–2013.

According to the Academy, “Centres of excellence are research units or researcher training units which comprise one or more high - level research teams that are at or near the international cutting edge of research in their field. They will also share a common set of objectives and work under the same management. Funding for centres of excellence comes not only from the Academy, but also from the host organizations of the units concerned, and possibly from other funding bodies, such as Tekes, business enterprises and foundations. A centre of excellence may be a unit of research teams working at both universities and research institutes.”

There are altogether 41 Centres of Excellence in Finland: the Academy Board has appointed 23 centres of excellence for the national centre of excellence programme in 2006–2011 and 18 for the years 2008–2013.

The current SMARAD was formed in 2006 by the Radio Laboratory, the Electronic Circuit Design Laboratory and the Signal Processing Laboratory of the Department of Electrical and Communications Engineering, Helsinki University of Technology (TKK). After the restructuring of the

TKK organization, SMARAD involves research groups from three departments, namely the Department of Radio Science and Engineering, Department of Micro and Nanosciences, and Department of Signal Processing and Acoustics, all within the Faculty of Electronics, Communications and Automation of the Aalto University School of Science and Technology.

SMARAD provides world-class research and education in RF, microwave and millimeter wave engineering, in integrated circuit design for multi-standard radios as well as in wireless communications. In microwave and millimeter wave engineering it is also the only research unit in Finland.

The total number of employees within the research unit is about 90 including about 30 senior scientists and about 40 graduate students and several undergraduate students working on their Master thesis. The unit conducts basic research but at the same time maintains close cooperation with industry. Novel ideas are applied in design of new communication circuits and platforms, transmission techniques, and antenna structures resulting also in patents and invention reports. 'Smart' in SMARAD's name refers to adaptability of antennas, radio devices, or materials to RF signals or fields.

10. Activity in Boards and Committees

10.1. University Boards

Anu Lehtovuori

- Member, ETA Committee for Doctoral Education
- Vice member, ETA Faculty Council

Keijo Nikoskinen

- Chairman, Committee for Quality of Teaching of the ETA Faculty
- Vice director, Department of Radio Science and Engineering

Antti Räisänen

- Chairman, TKK Dissertations Committee
- Member, TKK Education and Research Council
- Member, ETA Faculty Council
- Department head, Department of Radio Science and Engineering
- Director, SMARAD Center of Excellence
- Chairman, Board of Directors of MilliLab

Ari Sihvola

- Vice Chairman, Tenure Track Committee for filling three professor positions in computer science
- Member, Tenure Track Committee for filling two professor positions in signal processing and acoustics
- Member, Academic Affairs Committee of the Aalto University School of Science and Technology
- Member, Steering Group of the Teaching Evaluation Exercise of Aalto University
- Member, Aalto University Degree Committee

10.2. Other Boards and Activities

Martti Hallikainen

- Vice President and Treasurer, International Union of Radio Science (URSI)
- Member, URSI Long Range Planning Committee
- Chair, Publications Awards Committee, Institute of Electrical and Electronics Engineers (IEEE), Geoscience and Remote Sensing Society (GRSS)
- Member, IEEE GRSS Nominations Committee
- Member, European Association of Remote Sensing Laboratories (EARSeL) Council
- Vice Chair, Finnish National Committee of Commission for Space Research (COSPAR)
- Member, Executive Committee of Finnish National Committee of International Union of Radio Science (URSI)
- National Liaison, International Space University

- Finnish Delegate, European Space Agency (ESA) Data Operations Scientific and Technical Advisory Group (DOSTAG)
- Commission F Official Representative of Finland, International Union of Radio Science (URSI)
- TPC Member, IEEE 2010 International Geoscience and Remote Sensing Symposium (IGARSS'10), Hawaii, USA
- International Advisory Board Member, Progress in Electromagnetics Research Symposium 2010 (PIERS 2010), Xi'an, China
- Program Committee Member, European Conference on Synthetic Aperture Radar 2010 (EUSAR 2010), Aachen, Germany
- Scientific Committee Member, ESA Living Planet Symposium 2010, Bergen, Norway
- Member, Management Committee of EU Cost Action ES1001 SMOS Mission Oceanographic Data Exploitation
- Steering Committee Member, URSI Commission F Microwave Signatures 2010 Specialist Symposium on Microwave Remote Sensing of the Earth, Oceans and Atmosphere & VI CeTem-AIT Italian National Workshop on Microwave Remote Sensing, Florence, Italy
- International Advisory Committee Member, 6th International Conference on Microwaves, Antenna, Propagation & Remote Sensing (ICMARS-2010), Jodhpur, India
- Fellow, Institute of Electrical and Electronics Engineers (IEEE), Electromagnetics Academy

Kirsti Keltikangas

- Member of SEFI Working Group on Engineering Education Research

Janne Roos

- Member of the Program Committee, the 8th International Conference on Scientific Computing in Electrical Engineering (SCEE 2010)

Antti Räisänen

- Member of the Board of Directors, Member of the General Assembly, European Microwave Association (EuMA)
- Chairman of the EuMA Awards Committee
- Member of the TPC, 21st International Symposium on Space Terahertz Technology, ISSTT2010 (Oxford, UK, 23-25 March 2010)
- Member of the TPC, 4th European Conference on Antennas and Propagation, EuCAP2010 (Barcelona, Spain, 12-16 April, 2010)
- General Vice Chair, Global Symposium on Millimeter Waves, GSMM2010 (Incheon, Korea, April 14-16, 2010)
- Member of the Kenneth J Button Prize Committee, 35th International Conference on Infrared, Millimeter, and Terahertz Waves, IRMMW–THz 2010 (Rome, Italy, 5-10 September, 2010)
- Member of the TPC, 20th International Conference on Applied Electromagnetics and Communications, ICECom 2010 (Dubrovnik, Croatia, 20-22 September, 2010)
- Member of the TPC, European Microwave Week, EuMW2010 (Paris, France, 26 September – 1 October, 2010)
- Member of the TPC, 32nd ESA Antenna Workshop (ESTEC, Noordwijk, The Netherlands, 5-8 October, 2010)
- Member of the TPC, 32nd Annual Antenna Measurement Techniques Association (AMTA) Symposium (Atlanta, USA, 11-15 October, 2010)
- Fellow, Institute of Electrical and Electronics Engineers (IEEE)
- Edmond S. Gillespie Fellow, AMTA

Ari Sihvola

- Chairman, Finnish National Committee of International Union of Radio Science (URSI)
- Commission B Official Representative of Finland, International Union of Radio Science (URSI)
- Member, URSI Commission B Technical Advisory Board
- Member, the Governing Board, Federation of the Finnish Learned Societies

- Member, Steering Committee of the European Doctoral Programme on Metamaterials
- Director, National Graduate School in Electronics, Telecommunications and Automation GETA
- Member of the Technical Program Committee of PIERS conference, session chairman (Progress in Electromagnetics Research Symposium, Xian, China, March 2010)
- Member of the Technical Program Committee of PIERS conferences (Progress in Electromagnetics Research Symposium, Cambridge, Mass., USA, July 2010, and Suzhou, China, September 2011)
- Member of the Scientific Advisory Committee of META'10, session chairman (2nd International Conference on Metamaterials, Photonic Crystals and Plasmonics) Conference (Cairo, Egypt, February 2010)
- Member of the Technical Program Committee, session convener and chairman, URSI International Symposium on Electromagnetic Theory (Berlin, August 2010)
- Member of the Advisory Board of Metamaterials 2010 congress (Karlsruhe, Germany, September 2010)
- Member of the International Steering Committee of the 2010 Asia–Pacific Radio Science Conference (Toyama, Japan, September 2010)
- Member of the Programme committee of Reflektori, Symposium of Engineering Education (December 2010, Espoo, Finland)
- Member of the organizing committee of the Science Forum – Science and everyday life ("Tieteen päivät", Helsinki, January 2011)
- Member of the International Advisory Committee of PIERS conference (Marrakesh, Morocco, March 2011)
- Member of the Organizing Committee, URSI General Assembly and Scientific Symposium (Istanbul, Turkey, August 2011)
- Member, Applied Computational Electromagnetics Society, American Association of Physics Teachers, Finnish Physical Society, Finnish Academy of Technology, Finnish Academy of Science and Letters
- Fellow, Institute of Electrical and Electronics Engineers (IEEE), Electromagnetics Academy

Sergei Tretyakov

- President, the Virtual Institute for Artificial Electromagnetic Materials and Metamaterials
- Member, Steering Committee of the European Doctoral Programme on Metamaterials
- Deputy member, URSI Finnish National Committee
- Fellow, Institute of Electrical and Electronics Engineers (IEEE), Electromagnetics Academy
- General chair, Fourth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics Karlsruhe, Germany, September 2010
- Member of the TPC and session chair: META'10, 2nd International Conference on Metamaterials, Photonic Crystals and Plasmonics, 22-25 February, 2010, Cairo, Egypt; SPIE Photonics Europe 2010, 12-16 April 2010, Brussels, Belgium
- Member of the TPC: CIMTEC'2010 International Ceramics Congress (5th forum on new materials), 13-18 June 2010, Montecatini Terme; 7th Kharkov Symposium on Physics and Engineering of Microwaves, Millimeter, and Submillimeter Waves (MSMW'10), and TERATECH'10, June 21-26, Kharkov; Loughborough Conference of Antennas and Propagation (LAPC), Loughborough, UK, November 8-9, 2010
- Member, Expert Advisory Group for Nanosciences, Nanotechnologies, Materials and New Production Technologies (European Commission, 7th Framework Programme)

Martti Valtonen

- Deputy Member, International Union of Radio Science (URSI) Finnish National Committee

Henrik Wallén

- Secretary, Finnish National Committee of International Union of Radio Science (URSI)

10.3. Review Activities

Juha Ala-Laurinaho

- Reviews for *IEEE Transactions on Antennas and Propagation, IEEE Antennas and Wireless Propagation Letters, Journal of Electromagnetic Waves and Applications, Progress in Electromagnetic Research*

Martti Hallikainen

- Editorial Board Member, EARSeL Book Series on Earth Observation/Remote Sensing
- Reviews for Research Council of Norway, Finnish Environment Institute, National Quality Excellence Award, IEEE Fellow Committee, IEEE Mikio Takagi Student Prize, IEEE Geoscience and Remote Sensing Society (GRSS) Awards including: Transactions Prize Paper Award, Letters Prize Paper Award, Symposium Prize Paper Award, Symposium Interactive Session Prize Paper Award, Student Prize Paper Awards
- Conference paper reviews for IEEE 2010 International Geoscience and Remote Sensing Symposium (IGARSS'10), ESA Living Planet Symposium 2010, European Conference on Synthetic Aperture Radar 2010 (EUSAR 2010), URSI Commission F Microwave Signatures 2010 Specialist Symposium on Microwave Remote Sensing of the Earth, Oceans and Atmosphere & VI CeTem-AIT Italian National Workshop on Microwave Remote Sensing

Jari Holopainen

- Reviews for *IEEE Transactions on Antennas and Propagation, IEEE Antennas and Wireless Propagation Letters*

Juha Kainulainen

- Reviews for *Remote Sensing*

Kirsti Keltikangas

- Reviews for *European Journal of Engineering Education*

Henrik Kettunen

- Reviews for *IEEE Transactions on Microwave Theory and Techniques, Journal of Nanomaterials,* and *2010 URSI International Symposium on Electromagnetic Theory*

Juha Mallat

- Reviews for *IEEE Microwave and Wireless Components Letters, International Journal of Microwave and Wireless Technologies*

Igor Nefedov

- Reviews for *Physical Review B, Optics Letters, Photonics and Nanostructures, Metamaterials*

Jiaran Qi

- Reviews for *Applied Computational Electromagnetics Society Journal, Progress in Electromagnetic Research, Journal of Electromagnetic Waves and Applications*

Antti Räisänen

- Editorial Board Member: *Experimental Astronomy, International Journal of Microwave, and Wireless Technologies*
- Evaluation for Technologiestichting STW, The Netherlands
- Evaluations for IEEE Fellow Committee, USA
- Evaluation for ESF Research Networking Programme, France
- Evaluation for a faculty position in Information and Communication Technology: Chalmers University of Technology, Sweden
- Reviews for *IEEE Transactions on Microwave Theory and Techniques, IEEE Transactions on Antennas and Propagation, IEEE Transactions on Instrumentation and Measurement, IEEE Microwave and Wireless Components Letters, IET Electronics Letters, IET Proceedings on Microwaves, Antennas and*

Propagation, Progress in Electromagnetics Research, Journal of Electromagnetic Waves and Applications, International Journal of Microwave, and Wireless Technologies
- Conference paper reviews: *ISSTT2010, EuCAP2010, EuMW2010, 32nd ESA Antenna Workshop, 32nd AMTA Symposium*

Ari Sihvola
- Editorial Board Member, *Sensing and Imaging; International Journal Physics, Mathematics and Technics Problems (Belarus)*
- Advisory Board Member, *Metamaterials* Journal
- Interrogator: licentiate thesis by Kristin Persson, "Retrieval of equivalent currents by the use of an integral representation and the extinction theorem—radome applications," Lund University, Sweden, 5.2.2010
- External reporter and committee member of the doctoral dissertation, "Electromagnetic wave propagation in complex media and metamaterials: a geometric algebra approach" of Mr. Sérgio de Almeida Matos, Technical University of Lisbon, Portugal, 10.9.2010
- External reporter and committee member of the doctoral dissertation, Modélisation et caractérisation spectrale de métamatériaux" of Mr. Mohamed Hicham Belyamoun, Université Pierre et Marie Curie, Paris, France, 1.12.2010
- Two evaluations for the Leverhulme Foundation (UK)
- Evaluations for the Israel Science Foundation, l'Institut Universitaire de France, Optical Society of America Award Committee
- Evaluations for faculty positions: Columbia University, Stanford University, Princeton University (USA)
- Evaluation for tenure/promotion to professor position, Northeastern University (USA)
- Reviews for *IEEE Transactions on Microwave Theory and Techniques, IEEE Transactions on Antennas and Propagation, IEEE Antennas and Propagation Magazine, IEEE Transactions on Dielectrics and Electrical Insulation, IEEE Microwave and Wireless Components Letters, Physica B: Condensed Matter, Journal of Nanomaterials, Optics Express, Applied Computational Electromagnetics Society Journal, Mathematical Problems in Engineering, Progress in Electromagnetics Research, Journal of Electromagnetic Waves and Applications*
- Conference paper reviews: *Applied Computational Electromagnetics Society Congress, URSI EMTS 2010, Metamaterials'2010, Reflektori*

Kimmo Silvonen
- Editorial Board Member, *IEEE Transactions on Microwave Theory and Techniques*
- Reviews for *IEEE Transactions on Microwave Theory and Techniques*

Sergei Tretyakov
- Editorial Board Member, *Progress in Electromagnetics Research, Problems of Physics, Mathematics, and Technics*
- Pre-examination of a doctoral thesis, Tel Aviv University, Israel
- Reviews for *Science, Nature, Nature Photonics, Nature Materials, Nature Communications, IEEE Transactions on Antennas and Propagation, Physical Review, Physical Review Letters, Journal of the Optical Society of America A and B, Optics Letters, Journal of Applied Physics, Metamaterials, Optics Express,* etc.

Pertti Vainikainen
- Review committee member for the PhD thesis defence of Ana Perez, Mälardalen Högskola, Västerås, Sweden
- Reviews for *IEEE Transactions on Instrumentation and Measurement, Wireless Personal Communications Electronics Letters, IEEE Antennas and Wireless Propagation Letters*

Constantinos Valagiannopoulos

- Reviews for *Research Journal of Earth and Planetary Sciences, Journal of Electromagnetic Waves and Applications, Progress In Electromagnetic Research*

Henrik Wallén

- Reviews for *IEEE Transactions on Antennas and Propagation, IEEE Microwave and Wireless Components Letters, Optics Express, International Journal of Microwave Science and Technology, Europhysics Letters*
- Conference paper reviews: URSI EMTS 2010
- Review of one book proposal for Wiley

Pasi Ylä-Oijala

- Reviews for *IEEE Transactions on Antennas and Propagation, IET Microwaves, Antennas, and Propagation, Engineering Analysis with Boundary Elements, Geoscience and Remote Sensing Letters, Applied Computational Electromagnetics Society Conference*

11. Publications

11.1 Books and Chapters in Books

1. J. Roos and L. R. J. Costa (editors), Mathematics in Industry 14: Scientific Computing in Electrical Engineering SCEE 2008. Berlin/Heidelberg: Springer, 2010.
2. T. Veijola, "Gas damping in vibrating MEMS structures," in Handbook of Silicon Based MEMS Materials and Technologies (V. Lindroos, M. Tilli, A. Lehto, and T. Motooka, eds.), Amsterdam, Elsevier, 2010, pp. 259-279.

11.2 Refereed Journal Articles

1. P. Alitalo, H. Kettunen, and S. Tretyakov, "Cloaking a metal object from an electromagnetic pulse: A comparison between various cloaking techniques," Journal of Applied Physics, vol. 107, no. 3, p. 034905, 2010.
2. P. Alitalo and S. Tretyakov, "Electromagnetic cloaking of strongly scattering cylindrical objects by a volumetric structure composed of conical metal plates," Physical Review B, vol. 82, p. 245111, 2010.
3. P. Belov, E. Yankovskaya, I. Melchakova, and C. Simovski, "Studying the possibility of extracting material parameters from reflection and transmission coefficients of plane wave for multilayer metamaterials based on metal nanogrids," Optics and Spectroscopy, vol. 109, no. 1, pp. 85-96, 2010.
4. L. Bergamin and T. Sammaraee, "Waved glass: Towards optimal light distribution on solar cell surfaces for high efficient modules," Solar Energy, vol. 84, no. 1, pp. 90-100, 2010.
5. L. R. J. Costa, K. Nikoskinen, and M. Valtonen, "A robust technique for modelling nonlinear lumped elements spanning multiple cells in FDTD," in Mathematics in Industry 14: Scientific Computing in Electrical Engineering SCEE 2008 (J. Roos and L. R. J. Costa, eds.), Berlin/Heidelberg, Springer, 2010, pp. 53-59.
6. G. De Pasquale, T. Veijola, and A. Somá, "Modelling and validation of air damping in perforated gold and silicon MEMS plates," Journal of Micromechanics and Microengineering, vol. 20, p. 015010, 2010.
7. E. Grossman, C. Dietlein, J. Ala-Laurinaho, M. Leivo, L. Grönberg, M. Grönholm, P. Lappalainen, A. Rautiainen, A. Tamminen, and A. Luukanen, "Passive terahertz camera for standoff security screening," Applied Optics, vol. 49, no. 19, p. 120, 2010.
8. M. Hallikainen, "Remote sensing activities in Finland 2010," EARSeL Newsletter, no. 84, pp. 9-12, 2010.
9. J. Holopainen, O. Kivekäs, C. Icheln, and P. Vainikainen, "Internal broadband antennas for digital television receiver in mobile terminals," IEEE Transactions on Antennas and Propagation, vol. 58, no. 10, pp. 3363-3374, 2010.
10. J. Holopainen, R. Valkonen, O. Kivekäs, J. Ilvonen, and P. Vainikainen, "Broadband equivalent circuit model for capacitive coupling element–based mobile terminal antenna," IEEE Antennas and Wireless Propagation Letters, vol. 9, pp. 716-719, 2010.
11. M. Honkala, P. Miettinen, J. Roos, and C. Neff, "Hierarchical model-order reduction flow," in Mathematics in Industry 14: Scientific Computing in Electrical Engineering SCEE 2008 (J. Roos and L. R. J. Costa, eds.), Berlin/Heidelberg, Springer, 2010, pp. 539-546.
12. P. Järvensivu, J. Ala-Laurinaho, K. Halonen, A. Karttunen, K. Kautio, V.-M. Kolmonen, M. Kyrö, M. Kärkkäinen, M. Lahti, A. Lamminen, D. Sandström, J. Säily, and M. Varonen, "Millimetriradio ratkaisee monta ongelmaa," Prosessori, no. 11, pp. 44-47, 2010.

13. K. Keltikangas and H. Wallén, “Electrical engineers' perceptions on education - electromagnetic field theory and its connection to working life,” European Journal of Engineering Education, vol. 35, no. 5, pp. 479-487, 2010.
14. S. P. Kiminki, J. Markkanen, and P. Ylä-Oijala, “Integral equation solution for the D'B' boundary condition,” IEEE Antennas and Wireless Propagation Letters, vol. 9, pp. 526-529, 2010.
15. T. Kiuru, K. Dahlberg, J. Mallat, A. Räisänen, and T. Närhi, “Noncontacting multiwaveguide-band backshort for millimeter wave applications,” IEEE Microwave Theory and Wireless Component Letters, vol. 20, no. 9, pp. 483-485, 2010.
16. V.-M. Kolmonen, P. Almers, J. Salmi, J. Koivunen, K. Haneda, A. Richter, F. Tufvesson, A. F. Molisch, and P. Vainikainen, “A dynamic dual-link wideband MIMO channel sounder for 5.3 GHz,” IEEE Transactions Instrumentation and Measurement, vol. 59, no. 4, pp. 873-883, 2010.
17. V.-M. Kolmonen, K. Haneda, T. Hult, J. Poutanen, F. Tufvesson, and P. Vainikainen, “Measurement-based evaluation of interlink correlation for indoor multi-user MIMO channels,” IEEE Antennas and Wireless Propagation Letters, vol. 9, pp. 311-314, 2010.
18. V.-M. Kolmonen, K. Haneda, J. Poutanen, F. Tufvesson, and P. Vainikainen, “A dual-link capacity analysis of measured time-variant radio indoor channels,” Electronic Letters, vol. 46, no. 8, pp. 592-593, 2010.
19. I. Laakso, T. Uusitupa, and S. Ilvonen, “Comparison of SAR calculation algorithms for the finite-difference time-domain method,” Physics in Medicine and Biology, vol. 55, no. 15, p. N421–N431, 2010.
20. T. Laitinen, S. Pivnenko, J. Nielsen, and O. Breinbjerg, “Theory and practice of the FFT/matrix inversion technique for probe-corrected spherical near-field antenna measurements with high-order probes,” IEEE Transactions on Antennas and Propagation, vol. 58, no. 8, pp. 2623-2631, 2010.
21. J. Leppävirta, H. Kettunen, and A. Sihvola, “Complex problem exercises in developing engineering students’ conceptual and procedural knowledge of electromagnetics,” IEEE Transactions on Education, Vol. 54, No. 1, pp. 63-66,2010.
22. I. V. Lindell and A. Sihvola, “Electromagnetic boundary conditions defined in terms of normal field components,” IEEE Transactions on Antennas and Propagation, vol. 58, no. 4, pp. 1128-1135, 2010.
23. I. V. Lindell and A. Sihvola, “Circular waveguide with DB-boundary conditions,” IEEE Transactions on Microwave Theory and Techniques, vol. 58, no. 4, pp. 903-909, 2010.
24. I. V. Lindell, “Class of electromagnetic SQ-media,” Progress in Electromagnetics Research, vol. 110, pp. 371-382, 2010.
25. O. Luukkonen, P. Alitalo, F. Costa, C. Simovski, A. Monorchio, and S. Tretyakov, “Experimental verification of the suppression of spatial dispersion in artificial plasma,” Applied Physics Letters, vol. 96, no. 8, p. 081501, 2010.
26. O. Luukkonen, C. Simovski, G. Granet, G. Goussetis, D. Lioubtchenko, A. Räisänen, and S. Tretyakov, “Corrections to “Simple and accurate analytical model of planar grids and high-impedance surfaces comprising metal strips or patches” [Jun 08 1624-1632],” IEEE Transactions on Antennas and Propagation, vol. 58, no. 6, pp. 2162-2162, 2010.
27. C. Menzel, T. Paul, C. Rockstuhl, T. Pertsch, S. Tretyakov, and F. Lederer, “Validity of effective material parameters for optical fishnet metamaterials,” Physical Review B, vol. 81, no. 3, p. 035320, 2010.
28. P. Miettinen, M. Honkala, and J. Roos, “Partitioning-based RL-in-RL-out MOR method,” in Mathematics in Industry 14: Scientific Computing in Electrical Engineering SCEE 2008 (J. Roos and L. R. J. Costa, eds.), Berlin/Heidelberg, Springer, 2010, pp. 547-554.
29. D. K. Morits and C. R. Simovski, “Negative effective permeability at optical frequencies produced by rings of plasmonic dimers,” Physical Review B (Condensed Matter and Materials Physics), vol. 81, p. 205112, 2010.
30. D. K. Morits and C. R. Simovski, “On electromagnetic characterization of planar and bulk metamaterials,” Physical Review B (Condensed Matter and Materials Physics), vol. 82, p. 165113, 2010.
31. S. Mühlig, C. Rockstuhl, J. Pniewski, C. Simovski, S. Tretyakov, and F. Lederer, “Three-dimensional metamaterial nanotips,” Physical Review B, vol. 81, no. 7, p. 075317, 2010.
32. I. Nefedov, “Electromagnetic waves propagating in a periodic array of parallel metallic carbon nanotubes,” Physical Review B, vol. 82, p. 155423, 2010.
33. M. Pitkonen, “A closed-form solution for the polarizability of a dielectric double half-cylinder,” Journal of Electromagnetic Waves and Applications, vol. 24, no. 8-9, pp. 1267-1277, 2010.

34. J. P. Pousi, D. V. Lioubtchenko, S. N. Dudorov, and A. V. Räisänen, "High permittivity dielectric rod waveguide as an antenna array element for millimeter waves," IEEE Transactions on Antennas and Propagation, vol. 58, pp. 714-719, 2010.
35. J. Qi, H. Kettunen, H. Wallén, and A. Sihvola, "Quasi-dynamic homogenization of geometrically simple dielectric composites," Applied Computational Electromagnetics Society Journal, vol. 25, no. 12, pp. 1036-1045, 2010.
36. J. Qi, H. Kettunen, H. Wallén, and A. Sihvola, "Compensation of Fabry-Pérot resonances in homogenization of dielectric composites," IEEE Antennas and Wireless Propagation Letters, vol. 9, pp. 1057-1060, 2010.
37. O. Renaudin, V.-M. Kolmonen, P. Vainikainen, and C. Oestges, "Non-stationary narrowband MIMO inter-vehicle channel characterization in the 5 GHz band," IEEE Transactions Vehicular Technology, vol. 59, no. 4, pp. 2007-2015, 2010.
38. J. Roos, M. Honkala, and P. Miettinen, "GABOR: Global-approximation-based order reduction," in Mathematics in Industry 14: Scientific Computing in Electrical Engineering SCEE 2008 (J. Roos and L. R. J. Costa, eds.), Berlin/Heidelberg, Springer, 2010, pp. 517-514.
39. A. Sihvola, I. V. Lindell, H. Wallén, and P. Ylä-Oijala, "Material realizations of perfect electric conductor objects," Applied Computational Electromagnetics Society Journal, vol. 25, no. 12, pp. 1007-1016, 2010.
40. A. Sihvola, J. Qi, and I. Lindell, "Bridging the gap between plasmonics and Zenneck waves," IEEE Antennas and Propagation Magazine, vol. 52, no. 1, pp. 124-136, 2010.
41. A. Sihvola, "Limiting responses of extreme-parameter particles in composites," European Physical Journal: Applied Physics, vol. 49, no. 33001, pp. 1-8, 2010.
42. C. R. Simovski, "On electromagnetic characterization and homogenization of nanostructured metamaterials," Journal of Optics. A, Pure and Applied Optics, vol. 13, pp. 013001(1-22), 2010.
43. C. Simovski and S. Tretyakov, "On effective electromagnetic parameters of artificial nanostructured magnetic materials," Photonics and Nanostructures – Fundamentals and Applications, vol. 8, pp. 254-263, 2010.
44. A. Tamminen, J. Ala-Laurinaho, J. Mallat, A. Luukanen, E. Grossman, and A. Räisänen, "Wide-band measurements of antenna-coupled microbolometers for THz imaging," Journal of The Korean Institute of Electromagnetic Engineering and Science, vol. 10, no. 3, pp. 132-137, 2010.
45. J. Toivanen, T. Laitinen, and P. Vainikainen, "Modified test zone field compensation for small-antenna measurements," IEEE Transactions on Antennas and Propagation vol. 58, no. 11, pp. 3471-3479, 2010.
46. J. Toivanen, R. A. E. Mäkinen, J. Rahola, S. Järvenpää, and P. Ylä-Oijala, "Gradient based shape optimization of UWB antennas parameterized using splines," IET Microwaves, Antennas & Propagation, vol. 4, no. 9, pp. 1406-1414, 2010.
47. T. Uusitupa, I. Laakso, S. Ilvonen, and K. Nikoskinen, "SAR variation study from 300 to 5000 MHz for 15 voxel models including different postures," Physics in Medicine and Biology, vol. 55, no. 4, pp. 1157-1176, 2010.
48. P. Ylä-Oijala, S. P. Kiminki, and S. Järvenpää, "Solving IBC-CFIE with dual basis functions," IEEE Transactions on Antennas and Propagation, vol. 58, no. 12, pp. 3997-4004, 2010.
49. P. Ylä-Oijala, V. Lancellotti, B. P. d Hon, and S. Järvenpää, "Domain decomposition methods combining surface equivalence principle and macro basis functions," Applied Computational Electromagnetics Society Journal, vol. 25, no. 12, pp. 1017-1025, 2010.
50. Y. Zhao, G. Palikaras, P. A. Belov, R. F. Dubrovka, C. R. Simovski, Y. Hao, and C. Parini, "Magnification of subwavelength field distributions using a tapered array of metallic wires with planar interfaces and an embedded dielectric phase compensator," New Journal of Physics, vol. 12, pp. 103045(1-10), 2010.
51. T. Zvolensky, D. Chicherin, A. Räisänen, and C. Simovski, "Leaky-wave regimes on MEMS-loaded transmission lines for mm-wave applications," Progress in Electromagnetics Research M, vol. 13, pp. 157-171, 2010.

11.3 Published Proceedings of International Conferences

1. J. Ala-Laurinaho, A. Karttunen, J. Säily, A. Lamminen, R. Sauleau, and A. Räisänen, "Mm-wave lens antenna with an integrated LTCC feed array for beam steering," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
2. P. Alitalo, A. Karilainen, T. Niemi, C. Simovski, S. Tretyakov, and P. de Maagt, "Chiral antennas radiating circularly polarized waves," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.

3. P. Alitalo, H. Kettunen, and S. Tretyakov, "A comparative study of cloaking of metal objects from electromagnetic pulses," in 2010 IEEE International Symposium on Antennas and Propagation and CNC-USNC/URSI Radio Science Meeting, Toronto, Canada, July 11-17, 2010.
4. P. Alitalo and S. Tretyakov, "Transmission-line cloaks of various electrical sizes," in 4th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics, Karlsruhe, Germany, September 13-16, 2010, pp. 761-763.
5. A. Bin Abdullah Al-Hadi, J. Ilvonen, R. Valkonen, J. Holopainen, O. Kivekäs, C. Icheln, and P. Vainikainen, "Performance analysis of broadband coupling element-based multiantenna structure for mobile terminal with hand effects," in The 21st IEEE Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC 2010), Istanbul, Turkey, IEEE, September 26-30, 2010, pp. 1111-1116.
6. A. Bin Abdullah Al-Hadi, J. Toivanen, T. Laitinen, P. Vainikainen, C. Xiaoming, N. Jamaly, J. Carlsson, P.-S. Kildal, and S. Pivnenko, "On diversity performance of two-element coupling element based antenna structure for mobile terminal," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010, p. 43.
7. K. Chalapat, S. Paraoanu, Z. Du, J. Tervo, I. Nefedov, and S. Tretyakov, "Unity absorbance layers - optimal design criteria," in 4th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics, Karlsruhe, German, Virtual Institute for Artificial Electromagnetic Materials and Metamaterials, September 13-16, 2010, pp. 279-281.
8. D. Chicherin, M. Sterner, J. Oberhammer, S. Dudorov, D. Lioubtchenko, A. Niskanen, V. Ovchinnikov, and A. Räisänen, "MEMS based high-impedance surface for millimetre wave dielectric rod waveguide phase shifter," in 40th European Microwave Conference, Paris, France, September 28-30, 2010.
9. D. Chicherin, M. Sterner, J. Oberhammer, S. Dudorov, D. Lioubtchenko, V. Ovchinnikov, and A. Räisänen, "MEMS tunable metamaterials surfaces and their applications," in Asia Pacific Microwave Conference, Yokohama, Japan, December 7-10, 2010, pp. 239-242.
10. D. Chicherin, M. Sterner, J. Oberhammer, S. Dudorov, J. Åberg, and A. V. Räisänen, "Analog type millimeter wave phase shifters based on MEMS tunable high-impedance surface in rectangular metal waveguide," in IEEE International Microwave Symposium, Anaheim, CA, USA, May 23-28, 2010, pp. 61-64.
11. K. Cools, F. Andriulli, P. Ylä-Oijala, H. Bagci, D. De Zutter, and E. Michielssen, "Improving the accuracy of the Calderon preconditioner CFIE by using a mixed discretization," in 2010 IEEE International Symposium on Antennas and Propagation and CNC-USNC/URSI Radio Science Meeting, Toronto, Canada, July 11-17, 2010.
12. K. Cools, F. Andriulli, P. Ylä-Oijala, J. Peeters, I. Bogaert, J. Fostier, and D. De Zutter, "Well-conditioned conforming boundary integral based solvers for the modeling of scattering by penetrable objects," in 2010 IEEE International Symposium on Antennas and Propagation and CNC-USNC/URSI Radio Science Meeting, Toronto, Canada, July 11-17, 2010.
13. L. R. J. Costa, M. Valtonen, and K. Nikoskinen, "An interface for FDTD-lumped circuit cosimulation," in The 8th International Conference on Scientific Computing in Electrical Engineering (SCEE 2010), Toulouse, France, September 19-24, 2010, pp. 31-32.
14. K. Dahlberg, T. Kiuru, J. Mallat, A. V. Räisänen, and T. Närhi, "Simple waveguide-to-suspended microstrip transition with low-pass filter," in 40th European Microwave Conference, Paris, France, September 28-30, 2010, pp. 671-674.
15. J. Dall'Amico, J. Kainulainen, A. Loew, and W. Mauser, "Comparing data of two airborne L-band radiometers with different spatial resolution over a heterogeneous land surface," in Proceedings of the 2010 IEEE International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, USA, IEEE, July 25-30, 2010, pp. 538-541.
16. M. Dashti, A. Khatun, T. Laitinen, A. Azremi, M. Ghoraishi, K. Haneda, and J.-I. Takada, "UWB ranging with antenna proximity to the human head," in 2010 Asia Pasific Microwave Conference (APMC 2010), Yokohama, Japan, December 7-10, 2010, pp. 2115-2118.
17. M. Dashti, T. Laitinen, M. Ghoraishi, K. Haneda, J.-i. Takada, and P. Vainikainen, "Antenna radiation pattern influence on UWB ranging accuracy," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
18. G. De Pasquale, T. Veijola, and A. Somá, "Energy dissipation associated with material damping on vibrating MEMS components," in Proceedings of Design, Test, Integration and Packaging of MESMS/MOEMS (DTIP 2010), Seville, Spain, May 5-7, 2010, pp. 99-104.
19. I. Fedosov, I. Nefedov, B. Khlebtsov, and V. Tuchin, "Optical tracking for measurements of nanoparticles diffusive and ordered motion," in Proceedings of International Conference on Nonlinear and Coherent Optics/Lasers, Applications and Technologies ICONO/LAT'2010, Kazan, Russia, August 23-26, 2010, p. LWC6.pdf.

20. S. Geng and P. Vainikainen, “Clustering characterization for UWB indoor communications,” in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
21. K. Guven, G. R. Saenz, E., E. Ozbay, and S. Tretyakov, “Metamaterial based cloaking with sparse distribution of spiral resonators (invited),” in Proc. of SPIE, vol. 7711 (Metamaterials V), Brussels, Belgium, April 12-16, 2010, p. 771111.
22. M. Hallikainen, J. Kainulainen, J. Seppänen, A. Hakkarainen, and K. Rautiainen, “Studies of radio frequency interference at L-band using an airborne 2-d interferometric radiometer,” in Proceedings of 2010 IEEE International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, IEEE Geoscience and Remote Sensing Society, July 25-30, 2010, pp. 2490-2491.
23. M. Hallikainen, J. Kainulainen, P. Sievinen, J. Seppänen, E. Rouhe, J. Dall’Amico, F. Schlenz, A. Loew, S. Bircher, and C. Montzka, “SMOS cal/val 2010 activities and RFI research with airborne HUT-2D radiometer,” in Abstracts of URSI Commission F Microwave Signatures 2010 Specialist Symposium on Microwave Remote Sensing of the Earth, Oceans, and Atmosphere & VI CeTeM-AIT Italian National Workshop on Microwave Remote Sensing, Florence, Italy, October 4-8, 2010, p. 5.
24. M. Hallikainen, K. Rautiainen, J. Kainulainen, and J. Seppänen, “Investigation of radio frequency interference at L-band using airborne radiometer data,” in 11th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment, Washington DC, US, March 1-4, 2010, p. 4.
25. M. Hallikainen, K. Rautiainen, J. Kainulainen, and J. Seppänen, “Use of HUT-2D airborne interferometric radiometer to support the SMOS mission,” in 11th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment, Washington DC, US, March 1-4, 2010, p. 5.
26. M. Hallikainen, “Progress and challenges in microwave remote sensing of northern areas,” in Abstracts of URSI Commission F Microwave Signatures 2010 Specialist Symposium on Microwave Remote Sensing of the Earth, Oceans, and Atmosphere & VI CeTeM-AIT Italian National Workshop on Microwave Remote Sensing, Florence, Italy, October 4-8, 2010.
27. M. Hallikainen, J. Kainulainen, P. Sievinen, J. Seppänen, E. Rouhe, J. Dall’Amico, F. Schlenz, A. Loew, S. Bircher, C. Montzka, “Supporting ESA SMOS Cal/Val 2010 activities with airborne HUT-2D interferometric radiometer,” in 2010 Finnish Remote Sensing Days, Espoo, November 4-5, 2010.
28. K. Haneda, E. Kahra, S. Wyne, C. Icheln, and P. Vainikainen, “Measurement of loop-back interference channels for outdoor-to-indoor full duplex radio relays,” in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
29. K. Haneda, J. Poutanen, L. Ling, C. Oestges, F. Tufvesson, and P. Vainikainen, “Comparison of angular and delay spreads between channel measurements and the COST channel model,” in IEEE Loughborough Antennas and Propagation Conference (LAPC), Loughborough, United Kingdom, November 8-9, 2010, pp. 477-480.
30. L. Hauhio, K. Keltikangas, A. Paloheimo, P. Pietikäinen, K. Vilonen, and E. Zitting, “Opetuksen tutkimuksen rooli Aalto-yliopistossa,” in ReflekTori 2010. Dipoli-raportit/Dipoli-Reports B 2010:1 (E. Myller, ed.), Espoo, Aalto University, Koulutuskeskus Dipoli, December 9-10, 2010, pp. 116-117.
31. L. Hauhio, K. Keltikangas, A. Paloheimo, P. Pietikäinen, K. Vilonen, and E. Zitting, “Engineering education research strategies in the Aalto University,” in Proceedings of the Joint International IGIP-SEFI Annual Conference. Diversity unifies - Diversity in Engineering Education, Brussels, Belgium, SEFI, September 19-22, 2010, p. 131.
32. J. Holopainen, R. Valkonen, O. Kivekäs, J. Ilvonen, L. Martinez, J. R. Kelly, and P. S. Hall, “Equivalent circuit model-based approach on the user body effect of a mobile terminal antenna,” in IEEE Loughborough Antennas and Propagation Conference (LAPC), Loughborough University, UK, November 8-9, 2010, pp. 217-220.
33. M. Hulkkonen, M. Honkala, J. Virtanen, and M. Valtonen, “Initialization of HB oscillator analysis from transient data,” in The 8th International Conference on Scientific Computing in Electrical Engineering (SCEE 2010), Toulouse, France, September 19-24, 2010, pp. 129-130.
34. T. Hult, F. Tufvesson, V.-M. Kolmonen, J. Poutanen, and K. Haneda, “Analytical dual-link MIMO channel model using correlated correlation matrices,” in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
35. J. Ilvonen, J. Holopainen, O. Kivekäs, R. Valkonen, C. Icheln, and P. Vainikainen, “Balanced antenna structures of mobile terminals,” in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.

36. R. Janssen, C. Tischendorf, W. Schoenmaker, H. G. Brachtendorf, E. Dautbegovic, T. Tinttunen, M. S. Soto, T. Rahkonen, R. Pulch, J. Virtanen, and J. ter Maten, “Integrated circuit/EM simulation and design technologies for advanced radio systems-on-chip,” in The 8th International Conference on Scientific Computing in Electrical Engineering (SCEE 2010), Toulouse, France, September 19-24, 2010, pp. 51-52.
37. J. Kainulainen and A. Colliander, “In-orbit performance of the SMOS reference radiometers — results from the early commissioning phase,” in Proceedings of 11th Specialist Meeting on Radiometry and Remote Sensing Applications 2010, Microrad´10, Washington DC, USA, March 1-4, 2010, pp. 5-10.
38. J. Kainulainen, M. Hallikainen, K. Rautiainen, E. Cardellach, F. Fabra, and A. Rius, “Study on correlation between airborne L-band radiometric measurements and GNSS-r observations at the Baltic Sea,” in URSI Commission F Microwave Signatures 2010 Specialist Symposium on Microwave Remote Sensing of the Earth, Florence, Italy, October 4-8, 2010, p. 58.
39. J. Kainulainen, K. Rautiainen, and M. Hallikainen, “L-band imaging radiometry with airborne HUT-2D interferometer - from the performance to remote sensing applications,” in Nordic Remote Sensing Days 2009, Book of Abstracts (J. Praks, M. Karjalainen, J. Koskinen, A. Leskinen, K. Luojus, E. Parmes, Y. Sucksdorff, M. Takala, and M. Törmä, eds.), Espoo, Finland, October 22-23, 2010, p. 67.
40. J. Kainulainen, K. Rautiainen, J. Lemmetyinen, J. Seppänen, M. Takala, and M. Hallikainen, “Radiometric performance of synthetic aperture radiometer HUT-2D -measurements of well-known natural sources,” in Proceedings of 11th Specialist Meeting on Radiometry and Remote Sensing Applications 2010, MicroRad´10, Washington, DC, USA, March 1-4, 2010, pp. 205-210.
41. J. Kainulainen, K. Rautiainen, P. Sievinen, J. Seppänen, E. Rouhe, M. Hallikainen, J. Dall'Amico, F. Schlenz, A. Loew, S. Bircher, and C. Montzka, “SMOS calibration and validation activities with airborne interferometric radiometer HUT-2D during spring 2010,” in Proceedings of the 2010 IEEE International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, USA, July 25-30, 2010, pp. 702-705.
42. J. Kainulainen, K. Rautiainen, M. Lankinen, E. Cardellach, F. Fabra, A. Rius, M. Hallikainen, “Study on correlation between airborne L-band radiometric measurements and GNSS-R observations at the Baltic Sea,” in 2010 Finnish Remote Sensing Days, Espoo, November 4-5, 2010.
43. A. Kallio, T. Veijola, J. Roos, M. Andersson, and M. Valtonen, “Lumped modelling of bisymmetrical four-port RF circuits,” in The 8th International Conference on Scientific Computing in Electrical Engineering (SCEE 2010), Toulouse, France, September 19-24, 2010, pp. 127-128.
44. A. Karttunen, J. Ala-Laurinaho, R. Sauleau, and A. Räisänen, “A study of extended hemispherical lenses for a high-gain beam-steering antenna,” in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
45. J. Kataja, “Shape optimization of wire dipole antennas,” in Proceedings of the 26th Annual Review of Progress in Applied Computational Electromagnetics, Tampere, Finland, April 26-29, 2010.
46. K. Keltikangas, “Electrical engineers' career paths - a narrative study on higher engineering education,” in Proceedings of the Joint International IGIP-SEFI Annual Conference. Diversity unifies - Diversity in Engineering Education, Brussels, Belgium, SEFI, September 19-22, 2010, p. 144.
47. H. Kettunen, J. Qi, H. Wallén, and A. Sihvola, “A glance at simple electromagnetic homogenization procedures,” in XXXII Finnish URSI Convention on Radio Science and Electromagnetics 2010 (E. Kaivanto and E. Salonen, eds.), Oulu, Finland, Aug 26, 2010, pp. 43-45.
48. H. Kettunen, J. Qi, H. Wallén, and A. Sihvola, “Homogenization of dielectric composites with finite thickness,” in Proceedings of the 26th Annual Review of Progress in Applied Computational Electromagnetics, Tampere, Finland, April 26-29, 2010, pp. 490-495.
49. H. Kettunen, J. Qi, H. Wallén, and A. Sihvola, “Limitations in homogenization of thin (meta)material slabs,” in Progress in Electromagnetics Research Symposium, Cambridge, USA, July 5-8, 2010, p. 673.
50. A. Khatun, T. Laitinen, and P. Vainikainen, “Spherical wave modelling of radio channels using linear scanners,” in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
51. A. Khatun, T. Laitinen, and P. Vainikainen, “Noise sensitivity analysis of spherical wave modelling of radio channels using linear scanners,” in 2010 Asia Pasific Microwave Conference (APMC 2010), Yokohama, Japan, December 7-10, 2010, pp. 2119-2122.

52. S. P. Kiminki, P. Ylä-Oijala, and J. Markkanen, "Surface integral equation methods for scattering problems expressed in terms of normal field components," in 2010 IEEE International Symposium on Antennas and Propagation and CNC-USNC/URSI Radio Science Meeting, Toronto, Canada, July 11-17, 2010.
53. T. Kiuru, K. Dahlberg, J. Mallat, A. Räisänen, and T. Närhi, "EH-impedance tuner with dielectric-based backshorts for millimetre wave diode testing," in 40th European Microwave Conference, Paris, France, September 28-30, 2010, pp. 1357-1360.
54. T. Kiuru, K. Dahlberg, J. Mallat, and A. Räisänen, "A method for determining the dielectric constant at millimeter wave frequencies," in Global Symposium on Millimeter Waves 2010 (GSMM2010), Incheon, South Korea, April 14-16, 2010.
55. V.-M. Kolmonen, K. Haneda, J. Poutanen, F. Tufvesson, and P. Vainikainen, "A dual-link capacity analysis of measured time-variant radio indoor channels," in 2010 IEEE Vehicular Technology Conference (VTC 2010-Spring), Taipei, Taiwan, May 16-19, 2010.
56. A. Kontu, J. Lemmetyinen, J. Pulliainen, K. Rautiainen, J. Kainulainen, and J. Seppänen, "L-band measurements of boreal soil," in Proceedings of the 2010 IEEE International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, USA, IEEE, July 25-30, 2010, pp. 706-709.
57. O. Kozina, L. Melnikov, and I. Nefedov, "Field propagation characteristics in optical metal-dielectric coaxial nano-waveguides," in Proceedings of International Conference on Nonlinear and Coherent Optics/Lasers, Applications and Technologies ICONO/LAT'2010, Kazan, Russia, August 23-26, 2010, p. IThO7.pdf.
58. M. Kyrö, S. Ranvier, V.-M. Kolmonen, K. Haneda, and P. Vainikainen, "Long range wideband channel measurements at 81-86 GHz frequency range," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
59. M. Kyrö, J. Simola, K. Haneda, S. Ranvier, P. Vainikainen, and K.-i. Takizawa, "60 GHz radio channel measurements and modeling in a shielded room," in 2010 IEEE Vehicular Technology Conference (VTC 2010-Spring), Taipei, Taiwan, May 16-19, 2010.
60. I. Laakso and T. Uusitupa, "Edge- or face-based electric field in FDTD: Implications for dosimetry," in 2010 Asia-Pacific Radio Science Conference Proceedings (K. Kobayashi, ed.), Toyama, Japan, The Institute of Electronics, Information and Communication Engineers (IEICE), September 22-26, 2010.
61. T. Laitinen, P. Kyösti, T. Jämsä, and P. Vainikainen, "Generation of a field with a laplacian-distributed power azimuth spectrum scattered by a single cluster in a MIMO-OTA test system based on multiple probe antennas," in 2010 Asia Pasific Microwave Conference (APMC 2010), Yokohama, Japan, December 7-10, 2010, pp. 2127-2130.
62. T. Laitinen, P. Kyösti, J.-P. Nuutinen, and P. Vainikainen, "On the number of OTA antenna elements for plane-wave synthesis in a MIMO-OTA test system involving a circular antenna array," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010, p. 82.
63. T. Laitinen, J. Toivanen, P. Kyösti, J.-P. Nuutinen, and P. Vainikainen, "On a MIMO testing based on multi-probe technology," in The 20th URSI Commission B International Symposium on Electromagnetic Theory (EMTS 2010), Berlin, Germany, August 16-19, 2010, pp. 256-259.
64. T. Laitinen, "Application of the iterative probe correction technique for compensating the effect of the mechanical alignment errors of probe in spherical near-field antenna measurements," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
65. I. V. Lindell, A. Sihvola, and H. Wallén, "Mixed-impedance boundary conditions," in Progress In Electromagnetics Research Symposium, Cambridge, USA, July 5-8, 2010, p. 711.
66. I. V. Lindell, "On the classification of electromagnetic media (invited)," in The 20th URSI Commission B International Symposium on Electromagnetic Theory (EMTS 2010), Berlin, Germany, August 16-19, 2010, pp. 767-770.
67. A. Luukanen, J. Ala-Laurinaho, M. Grönholm, P. Lappalainen, M. Leivo, A. Rautiainen, A. Tamminen, A. Räisänen, C. Dietlein, and E. Grossman, "Passive, video-rate THz imaging system for stand-off security screening," in Proceedings of Global Symposium on Millimeter Waves 2010, Incheon, South Korea, April 14-16, 2010, pp. 13-15.
68. A. Luukanen, L. Grönberg, M. Grönholm, P. Lappalainen, M. Leivo, A. Rautiainen, A. Tamminen, J. Ala-Laurinaho, C. Dietlein, and E. Grossman, "Real-time passive terahertz imaging system for standoff concealed weapons imaging," in Proceedings of SPIE, Orlando, Florida, USA, April 5-9, 2010.
69. A. Luukanen, M. Grönholm, P. Lappalainen, M. Leivo, A. Rautiainen, A. Tamminen, J. Ala-Laurinaho, A. Räisänen, C. Dietlein, and E. Grossman, "Passive real-time submillimetre-wave imaging system utilizing antenna-coupled microbolometers for stand-off security

screening applications," in International Workshop on Antenna Technology iWAT, Lisbon, Portugal, March 1-3, 2010.

70. O. Luukkonen, P. Alitalo, F. Costa, C. Simovski, and S. Tretyakov, "Experimental validation of the suppression of spatial dispersion in artificial plasma," in 2010 IEEE International Symposium on Antennas and Propagation and CNC-USNC/URSI Radio Science Meeting, Toronto, Canada, IEEE, July 11-17, 2010.
71. O. Luukkonen, A. Karilainen, J. Vehmas, C. Simovski, and S. Tretyakov, "A high-impedance surface based antenna - lose the antenna," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
72. O. Luukkonen, A. Karilainen, J. Vehmas, and S. Tretyakov, "A tri-band low-profile antenna based on a high-impedance surface," in 2010 IEEE International Symposium on Antennas and Propagation and CNC-USNC/URSI Radio Science Meeting, Toronto, Canada, IEEE, AP-S, July 11-17, 2010.
73. O. Luukkonen, C. Simovski, and S. Tretyakov, "Analytical modeling of artificial impedance surfaces," in Abstracts of the International Conference Days on Diffraction-2010, St. Petersburg, Russia, June 5-8, 2010, pp. 113-114.
74. Y. Maksimovitch, V. Mikhnev, and P. Vainikainen, "Study of effect of corrugated edges on the radiation characteristics of GPR antenna," in Proceedings of the 18th International Conference on Microwave, Radar and Wireless Communications (MIKON-2010), Vilnius, Lithuania, 14–15. June 2010.
75. Y. Maksimovitch, V. Mikhnev, and P. Vainikainen, "Study of different configurations of tapered-slot antenna arrays for detecting buried objects," in Proceedings of the 7th European Radar Conference, Paris, France, September 30 - October 1, 2010.
76. J. Markkanen, P. Ylä-Oijala, and A. Sihvola, "Surface integral equation methods for scattering by DB objects," in The 26th International Review of Progress in Applied Computational Electromagnetics (ACES 2010), Tampere, Finland, April 26-29, 2010, pp. 254-259.
77. M. Martin-Neira, I. Corbella, F. Torres, F. Cabot, J. Closa, J. Kainulainen, R. Castro, J. Barbosa, A. Gutierrez, F. Martin-Porqueras, R. Oliva, E. Anterrieu, M. Brown, and K. McMullan, "SMOS payload performance assessment," in Proceedings of the 2010 IEEE International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, USA, IEEE, July 25-30, 2010, pp. 3150-3153.
78. F. Martin-Porqueras, J. Kainulainen, M. Martin-Neira, I. Corbella, R. Oliva, R. Castro, J. Barbosa, and A. Gutierrez, "Experimental validation of the Corbella's visibility function using HUT-2D and MIRAS," in Proceedings of the 2010 IEEE International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, USA, IEEE, July 25-30, 2010, pp. 4286-4289.
79. P. Miettinen, M. Honkala, J. Roos, and M. Valtonen, "Improving model-order reduction methods by singularity exclusion," in The 8th International Conference on Scientific Computing in Electrical Engineering (SCEE 2010), Toulouse, France, September 19-24, 2010, pp. 137-138.
80. P. Miettinen, M. Honkala, J. Roos, and M. Valtonen, "Partitioning-based reduction of circuits with mutual inductances," in The 8th International Conference on Scientific Computing in Electrical Engineering (SCEE 2010), Toulouse, France, September 19-24, 2010, pp. 43-44.
81. V. Mikhnev, V. Badeev, and P. Vainikainen, "Microwave visualization of layered dielectric half-space using range profiling of phase," in Proceedings of the 11th International Radar Symposium (IRS 2010), Vilnius, Lithuania, 16–18. June 2010, pp. 396-399.
82. V. Mikhnev and P. Vainikainen, "Characterization of underground objects in UWB GPR by range profiling of phase," in Proceedings of the 7th European Radar Conference, Paris, France, September 30 - October 1, 2010.
83. I. Nefedov and S. Tretyakov, "Effective medium model for two-dimensional periodic arrays of carbon nanotubes," in Proc. of the third Int. Workshop on Theoretical and Computational Nanophotonics, Bad Honnef, Germany, 3.-5. November 2010, pp. 70-72.
84. I. Nefedov, "Electromagnetic waves transmission through a carbon nanotube slab: theoretical model of a carbon nanotube terahertz polarizer," in 4th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics (Metamaterials 2010), Karlsruhe, Germany, September 13-16, 2010, pp. 693-695.
85. P. Padilla, J. P. Pousi, A. Tamminen, J. Mallat, J. Ala-Laurinaho, M. Sierra-Castañer, and A. Räisänen, "Mm-wave DRW antenna phase centre determination," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010, p. 64.

86. S. Pivnenko, J. Zhang, A. Khatun, T. Laitinen, and J. Carlsson, "Characterization of small antennas for hearing aids by several measurement techniques," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
87. S. Pivnenko and T. Laitinen, "Fast pattern measurement of electrically large antennas by spherical near-field technique," in 31st ESA Antenna Workshop, Noordwijk, The Netherlands, October 5-8, 2010.
88. J. P. Pousi, S. Dudorov, D. Lioubtchenko, and A. Räisänen, "Frequency selective coupler for W band based on power transfer in dielectric rod waveguides," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010, p. 17.
89. J. Praks, M. Hallikainen, and E. Colin Koeniguer, "Polarimetric SAR image visualization and interpretation with covariance matrix invariants," in Proceedings of 2010 IEEE International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, USA, IEEE Geoscience and Remote Sensing Society, July 25-30, 2010, pp. 2035-2038.
90. J. Qi, H. Kettunen, H. Wallén, and A. Sihvola, "Frequency dependence of effective permittivity of simple dielectric composites," in The 26th International Review of Progress in Applied Computational Electromagnetics (ACES 2010), Tampere, Finland, April 26-29, 2010, pp. 248-253.
91. J. Qi, H. Kettunen, H. Wallén, and A. Sihvola, "Different retrieval methods based on s-parameters for the permittivity of composites," in The 20th URSI Commission B International Symposium on Electromagnetic Theory (EMTS 2010), Berlin, Germany, August 16-19, 2010, pp. 650-653.
92. K. Rautiainen, J. Lemmetyinen, A. Kontu, J. Pulliainen, J. Kainulainen, J. Seppänen, and M. Hallikainen, "Passive radiometric measurements of the polar regions using tower-based, airborne, and spaceborne L-band instruments," in URSI Commission F Microwave Signatures 2010 Specialist Symposium on Microwave Remote Sensing of the Earth, Florence, Italy, October 4-8, 2010, p. 81.
93. O. Renaudin, V.-M. Kolmonen, P. Vainikainen, and C. Oestges, "Impact of correlation matrix estimation accuracy on the computation of stationarity intervals," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
94. O. Renaudin, V.-M. Kolmonen, P. Vainikainen, and C. Oestges, "About the multipath stationarity of car-to-car channels in the 5 GHz band," in The 20th URSI Commission B International Symposium on Electromagnetic Theory (EMTS 2010), Berlin, Germany, August 16-19, 2010, pp. 872-875.
95. A. Richter, J. Salmi, and V.-M. Kolmonen, "Time evolution of dense multipath statistics," in Proceedings of The 4th European Conference on Antennas and Propagation, (EuCAP2010), Barcelona, Spain, April 12-16, 2010, April 12-16, 2010.
96. C. Rockstuhl, C. Menzel, T. Paul, T. Pertsch, S. Tretyakov, and F. Lederer, "How feasible are effective material parameters for metamaterials?," in 2nd International Conference on Metamaterials, Cairo, Egypt, February 22-25, 2010.
97. J. Roos, L. R. J. Costa, and M. Valtonen, "On circuit-level behavioral modeling of RF power amplifiers using dynamic neural networks," in The 8th International Conference on Scientific Computing in Electrical Engineering (SCEE 2010), Toulouse, France, September 19-24, 2010, pp. 87-88.
98. E. Rouhe and M. Hallikainen, "Aalto University's remote sensing aircraft," in 2010 Finnish Remote Sensing Days, Espoo, Finland, November 4-5, 2010.
99. A. Räisänen, J. Ala-Laurinaho, A. Karttunen, J. Mallat, A. Tamminen, and M. Vaaja, "Measurements of high-gain antennas at THz frequencies," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
100. A. Räisänen, J. Ala-Laurinaho, A. Karttunen, J. Mallat, A. Tamminen, and M. Vaaja, "High-gain antenna measurements at THz," in Proceedings of Global Symposium on Millimeter Waves 2010, Incheon, South Korea, April 14-16, 2010, pp. 259-260.
101. J. Salmi, J. Poutanen, K. Haneda, A. Richter, V.-M. Kolmonen, and P. Vainikainen, "Incorporating diffuse scattering in geometry-based stochastic MIMO channel models," in Proceedings of The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010, April 12-16, 2010.
102. C. Schmidt, T. Laitinen, and T. Eibert, "Fast Fourier transform preprocessing for accelerated plane wave based spherical near-field far-field transformation," in The 20th URSI Commission B International Symposium on Electromagnetic Theory (EMTS 2010), Berlin, Germany, August 16-19, 2010, pp. 851-854.
103. J. Seppänen, J. Kainulainen, M. Vaaja, A. Hakkarainen, and M. Hallikainen, "A microwave transmitter for examining the effects of interfering signal sources on interferometric

radiometer measurements," in 2010 Finnish Remote Sensing Days, Espoo, Finland, November 4-5, 2010.
104. A. Sihvola and I. Lindell, "The varieties of boundary conditions in electromagnetics," in The 26th International Review of Progress in Applied Computational Electromagnetics (ACES 2010), Tampere, Finland, April 26-29, 2010, p. 2.
105. A. Sihvola, J. Qi, and I. V. Lindell, "Confinement and propagation relations for Zenneck surface waves," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010, p. 1849170 (4).
106. A. Sihvola and J. Qi, "Relaxation and resonance as dispersion mechanisms in mixtures," in Progress In Electromagnetics Research Symposium (PIERS 2010), Xian, China, March 22-26, 2010, p. 46.
107. A. Sihvola, H. Wallén, P. Ylä-Oijala, and I. V. Lindell, "Approximating ideal boundary conditions in electromagnetics with penetrable interfaces," in XXXII Finnish URSI Convention on Radio Science and Electromagnetics 2010, Oulu, Finland, Aug 26, 2010, pp. 87-88.
108. A. Sihvola, "Olyslager approach to bianisotropic mixtures," in The 20th URSI Commission B International Symposium on Electromagnetic Theory (EMTS 2010), Berlin, Germany, August 16-19, 2010, pp. 771-774.
109. A. Sihvola, "The medium is not always the message," plenary keynote talk in 2nd International Conference on Metamaterials, Cairo, Egypt, February 22-25, 2010.
110. C. Simovski, J. Pniewski, S. Mühlig, and C. Rockstuhl, "Prospective metamaterials for local field enhancement," in Proceedings International Conference on Nonlinear and Coherent Optics/Lasers, Applications and Technologies ICONO/LAT'2010 (S. Bagayev, ed.), Kazan, Zavoiski Physical-Technical Institute, Russian Academy of Sciences, August 23-26, 2010, pp. 461-463.
111. C. Simovski, J. Pniewski, S. Mühlig, and C. Rockstuhl, "Multifrequency local field enhancement by a metamaterial nanopyramid," in Proceedings of the Days of Diffraction (V. Babich, ed.), St. Petersburg, Steklov Institute, Russian Academy of Sciences, June 5-8, 2010, pp. 78-80.
112. C. Simovski and S. Tretyakov, "On electromagnetic characterization of metamaterials (invited)," in Abstracts of the International Conference Days on Diffraction-2010, St. Petersburg, Russia, June 5-8, 2010, pp. 127-128.
113. C. Simovski and S. Tretyakov, "On electromagnetic characterization of nanostructured metamaterials," in Proc. of the Fourth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics (Metamaterials'2010), Karlsruhe, Germany, Metamorphose Virtual Institute, September 13-16, 2010, pp. 336-338.
114. M. Sterner, D. Chicherin, A. Räisänen, G. Stemme, and J. Oberhammer, "Reliability investigation of stress-compensated metal-coated monocrystalline-silicon membranes for MEMS tuneable high-impedance surfaces," in MEMSWAVE Conference, Otranto, Italy, June 28-30, 2010.
115. M. Sterner, D. Chicherin, A. Räisänen, G. Stemme, and J. Oberhammer, "RF MEMS high-impedance tuneable metamaterials for millimeter-wave beam steering," in GigaHertz Symposium, Lund, Sweden, March 9-10, 2010.
116. M. Sterner, D. Chicherin, J. Åberg, R. Sauleau, A. V. Räisänen, G. Stemme, and J. Oberhammer, "Integration of microwave MEMS reconfigurable reflective surfaces in rectangular waveguide stubs for W-band phase-shifters," in Asia Pacific Microwave Conference, Yokohama, Japan, December 7-10, 2010, pp. 1825-1828.
117. A. Tamminen, J. Ala-Laurinaho, J. Mallat, A. Luukanen, E. Grossman, and A. Räisänen, "Wide-band measurements of antenna-coupled microbolometers for THz imaging," in Proceedings of Global Symposium on Millimeter Waves 2010, Incheon, South Korea, April 14-16, 2010, pp. 245-248.
118. A. Tamminen, J. Ala-Laurinaho, and A. Räisänen, "Indirect holographic imaging: evaluation of image quality at 310 GHz," in SPIE Defense, Orlando, Florida, USA, April 5-9, 2010, pp. 7670-09.
119. A. Tamminen, J. Ala-Laurinaho, and A. Räisänen, "Submillimeter-wave power measurements with commercial infra-red detectors," in Proceedings of The 6th European Radar Conference, Paris, France, European Microwave Association, September 30 - October 1, 2010, pp. 288-291.
120. J. Toivanen, J. Rahola, R. A. E. Mäkinen, S. Järvenpää, and P. Ylä-Oijala, "Gradient based antenna shape optimization using spline curves," in The 26th International Review of Progress in Applied Computational Electromagnetics (ACES 2010), Tampere, Finland, April 26-29, 2010.

121. S. Tretyakov, P. Alitalo, O. Luukkonen, C. Simovski, and H. Kettunen, “Cloaking with simple metal structures (plenary keynote talk),” in 2nd International Conference on Metamaterials, Cairo, Egypt, February 22-25, 2010.
122. S. Tretyakov, I. Nefedov, P. Alitalo, and S. Maslovski, “Transforming electromagnetic fields (invited),” in SPIE Photonics Europe, Brussels, Belgium, April 12-16, 2010.
123. S. Tretyakov, “Cloaking and invisibility from microwaves to optics (keynote talk),” in Proc. of 3rd Mediterranean Conference on Nanophotonics, MediNano-3, Belgrade, Serbia, 18-19 October, 2010, p. 6.
124. S. Tretyakov, “New concepts of microwave and optical cloaking (invited),” in Abstracts of 5th Forum on New Materials (CIMTEC 2010), Montecatini Terme, Italy, June 13-18, 2010, p. 107.
125. S. Tretyakov, “Possibilities of cloaking and invisibility at microwaves (invited),” in Abstracts of the International Conference Days on Diffraction-2010, St. Petersburg, Russia, June 5-8, 2010, pp. 131-132.
126. S. Tretyakov, “The optimal material for interactions with linearly-polarized electromagnetic waves (invited),” in Proc. of the Fourth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics (Metamaterials'2010), Karlsruhe, Germany, Metamorphose Virtual Institute, September 13-16, 2010, pp. 65-67.
127. S. Tretyakov, “Possibilities of cloaking and invisibility at microwaves (invited),” in Proceedings of the 40th European Microwave Conference, Paris, France, EuMA, September 28-30, 2010, p. 350.
128. P. Vainikainen, V. Mikhnev, T. Laitinen, Y. Maksimovitch, and V.-M. Kolmonen, “Future measurement applications of broadband sensor arrays,” in Proceedings of the Symposium Organised in the Occasion of the Retirement of Professor Leo P. Ligthart, Delft, the Netherlands, December 9, 2010, pp. 37-46.
129. R. Valkonen, C. Luxey, J. Holopainen, C. Icheln, and P. Vainikainen, “Frequency-reconfigurable mobile terminal antenna with MEMS switches,” in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.
130. R. Valkonen, S. Myllymäki, A. Huttunen, J. Holopainen, J. Ilvonen, P. Vainikainen, and H. Jantunen, “Compensation of finger effect on a mobile terminal antenna by antenna selection,” in 2010 International Conference on Electromagnetics in Advanced Applications (ICEAA'10 Offshore), Sydney, Australia, September 20-24, 2010, pp. 364-367.
131. A. Vinogradov, A. Merzlikin, C. Simovski, S. Tretyakov, and S. Zouhdi, “Homogenization of metamaterials: bulk properties and boundary conditions (keynote talk),” in 2nd International Conference on Metamaterials, Cairo, Egypt, February 22-25, 2010.
132. J. Virtanen, J. ter Maten, M. Honkala, and M. Hulkkonen, “Estimation of initial conditions for harmonic balance analysis of free-running oscillators,” in Program & Book of Abstracts of the 16th European Conference on Mathematics for Industry (ECMI2010) (M. Günther and M. Striebel, eds.), Wuppertal, Germany, July 26-30, 2010, pp. 131-132.
133. A. von Lerber, T. Piepponen, J. Koskinen, D. Moisseev, A. Kestilä, J. Tyynelä, T. Nousiainen, J. Koistinen, A. Sihvola, P. Ylä-Oijala, J. Praks, M. Hallikainen, and J. Pulliainen, “Modeling attenuation of melting hydrometeors with a method based on volume integral equations,” in Proceedings of the 2010 IEEE International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, USA, July 25-30, 2010, pp. 2355-2358.
134. H. Wallén, H. Kettunen, J. Qi, and A. Sihvola, “Some interesting effects when modeling plasmonic composites,” in XXXII Finnish URSI Convention on Radio Science and Electromagnetics 2010 (E. Kaivanto and E. Salonen, eds.), Oulu, Finland, Aug 26, 2010, pp. 47-50.
135. H. Wallén, H. Kettunen, J. Qi, and A. Sihvola, “A geometrically simple benchmark problem for negative index metamaterial homogenization,” in 2010 URSI International Symposium on Electromagnetic Theory, Berlin, Germany, August 16-19, 2010, pp. 923-926.
136. H. Wallén, I. V. Lindell, and A. Sihvola, “Mie scattering and (ab)normal boundary conditions,” in 2nd International Conference on Metamaterials, Cairo, Egypt, February 22-25, 2010, 1 page.
137. H. Wallén, “A simple model problem for benchmarking metamaterial homogenization theories,” in Proceedings of 2010 IEEE AP-S/URSI, Toronto, Canada, July 11-17, 2010, p. 504.1.
138. A. B. Yakovlev, M. G. Silveirinha, O. Luukkonen, C. R. Simovski, I. S. Nefedov, and S. A. Tretyakov, “Simple and efficient solution for mushroom surfaces - local versus nonlocal homogenization (invited),” in Proc. of 4th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics, Karlsruhe, Germany, Metamorphose, September 13-16, 2010.
139. J. Yang, S. Pivnenko, T. Laitinen, J. Carlsson, and X. Chen, “Measurements of diversity gain and radiation efficiency of the eleven antenna by using different measurement techniques in

ETECH project," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.

140. P. Ylä-Oijala, S. P. Kiminki, J. Markkanen, H. Wallén, A. Sihvola, I. Lindell, and S. Järvenpää, "Numerical methods for scattering problems expressed in terms of normal field components and their normal derivatives," in The 20th URSI Commission B International Symposium on Electromagnetic Theory (EMTS 2010), Berlin, Germany, August 16-19, 2010.
141. P. Ylä-Oijala, S. P. Kiminki, K. Cools, F. Andriulli, and S. Järvenpää, "Mixed discretization schemes for combined field integral equations," in 2010 IEEE International Symposium on Antennas and Propagation and CNC-USNC/URSI Radio Science Meeting, Toronto, Canada, July 11-17, 2010.
142. P. Ylä-Oijala and S. P. Kiminki, "Calderon preconditioned electric current formulation," in The 20th URSI Commission B International Symposium on Electromagnetic Theory (EMTS 2010), Berlin, Germany, August 16-19, 2010.
143. P. Ylä-Oijala and S. P. Kiminki, "On the Calderon multiplicative preconditioner for composite conducting and dielectric objects," in 2010 IEEE International Symposium on Antennas and Propagation and CNC-USNC/URSI Radio Science Meeting, Toronto, Canada, July 11-17, 2010.
144. P. Ylä-Oijala, V. Lancellotti, B. P. de Hon, and S. Järvenpää, "Solving complex electromagnetic problems with domain decomposition methods based on surface equivalence principle," in The 26th International Review of Progress in Applied Computational Electromagnetics (ACES 2010), Tampere, Finland, April 26-29, 2010.
145. T. Zvolensky, D. Chicherin, A. Räisänen, and C. Simovski, "Beam-steering MEMS-loaded antenna based on planar transmission lines," in The 4th European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, April 12-16, 2010.

11.4 Other presentations at Scientific Meetings

1. T. Hult, F. Tufvesson, V.-M. Kolmonen, J. Poutanen, and K. Haneda, "Analytical dual-link MIMO channel model using correlated correlation matrices," COST 2100 Meeting tech. rep., Athens, Greece, 2-5 Feb. 2010, TD(10)10052.
2. V.-M. Kolmonen, K. Haneda, T. Hult, J. Poutanen, F. Tufvesson, and P. Vainikainen, "Measurement-based evaluation of interlink correlation for indoor multi-user MIMO channels," COST 2100 Meeting tech. rep., Athens, Greece, 2-5 Feb. 2010, TD(10)10070.
3. O. Renaudin, V.-M. Kolmonen, P. Vainikainen, and C. Oestges, "Description of the August 2009 car-to-car radio channel measurement campaign," COST 2100 Meeting tech. rep., Athens, Greece, 2-5 Feb, 2010, TD(10)10013.
4. M. Kyrö, K. Haneda, J. Simola, P. Vainikainen, K.-i. Takizawa, and H. Hagiwara, "60 GHz radio channel measurements and modelling in hospital environments," COST 2100 11th Management Committee Meeting, Aalborg, Denmark, 2010, TD(10)11049.

11.5 Refereed Reports

1. V.-M. Kolmonen, "Propagation channel measurement system development and channel characterization at 5.3 GHz," R12, TKK Radio Science and Engineering Publications, Espoo, 2010, 110 pp.
2. E. Nieppola, "Synchrotron emission from blazar jets — energy distributions and radio variability," R15, TKK Radio Science and Engineering Publications, Espoo, 2010, 162 pp.
3. M. Pitkonen, "Exact solutions to some spherical electrostatic scattering problems," R14, TKK Radio Science and Engineering Publications, Espoo, 2010, 66 pp.
4. J. P. Pousi, "Active and passive dielectric rod waveguide components for millimetre wavelengths," R18, TKK Radio Science and Engineering Publications, Espoo, 2010, 204 pp.
5. J. Toivanen, "Measurement methods for mobile terminal antenna performance," R17, TKK Radio Science and Engineering Publications, Espoo, 2010, 132 pp.

11.6 Other Articles and Books

1. M. Hallikainen, "GRS-S publications awards presented at IGARSS 2010 banquet," IEEE Geoscience and Remote Sensing Society Newsletter, no. 4, pp. 26-33, 2010.
2. J. Praks, M. Karjalainen, J. Koskinen, A. Leskinen, K. Luojus, E. Parmes, Y. Sucksdorff, M. Takala, and M. Törmä, "Nordic Remote Sensing Days 2009. Book of abstracts," No. R13 in TKK Radio Science and Engineering Publications, Espoo, Finland, 2010.
3. A. Sihvola and S. Lindberg, "Aalto University school of science and technology department of radio science and engineering research and education 2009," No. R16 in TKK Radio Science and Engineering Publications, Espoo, 2010, 86 p.

4. S. A. Tretyakov, C. Rockstuhl, A. Sihvola, M. Kafesaki, C. Craeye, V. V. Kruglyak, "Basic theory of nanostructured metamaterials." Chapter 1 in *Nanostructured Metamaterials, Studies and reports*, European Commission, Directorate-General for Research, Unit G3, 2010, pp. 12-59.
5. T. Uusitupa, "An uncertainty estimate of SAR for Virtual Family Male" (for users of IEC 62232, an international standard on exposure estimation protocols), several documents available on: http://www.virtualman.info/order.cfm.

In times when university structures and their environments change, it is critical to document the state and achievements of units that form the core of these organizations. The present annual report describes the activities of the Department of Radio Science and Engineering of Aalto University for the year 2010.

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